JOURNAL OF DAIRY SCIENCE

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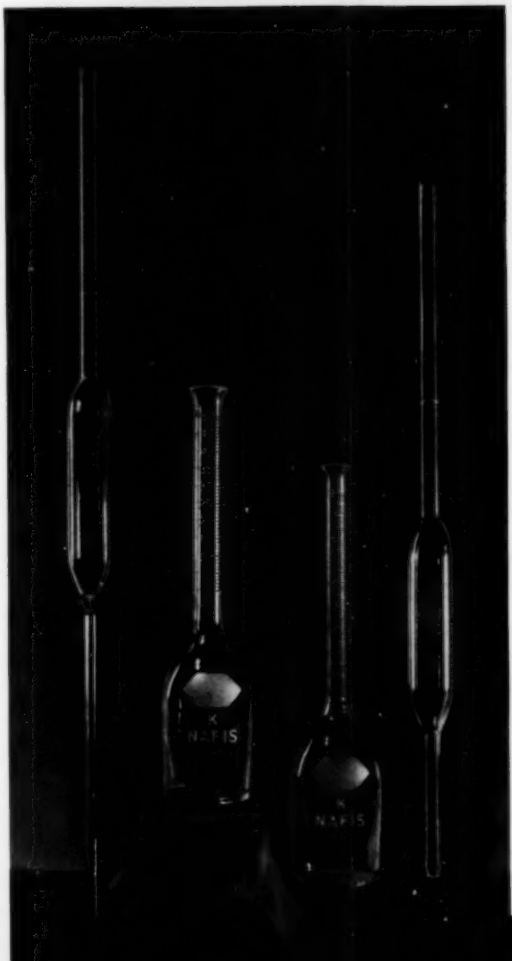

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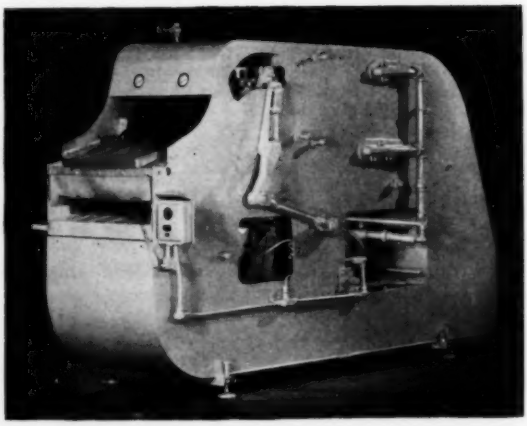

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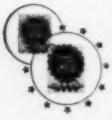

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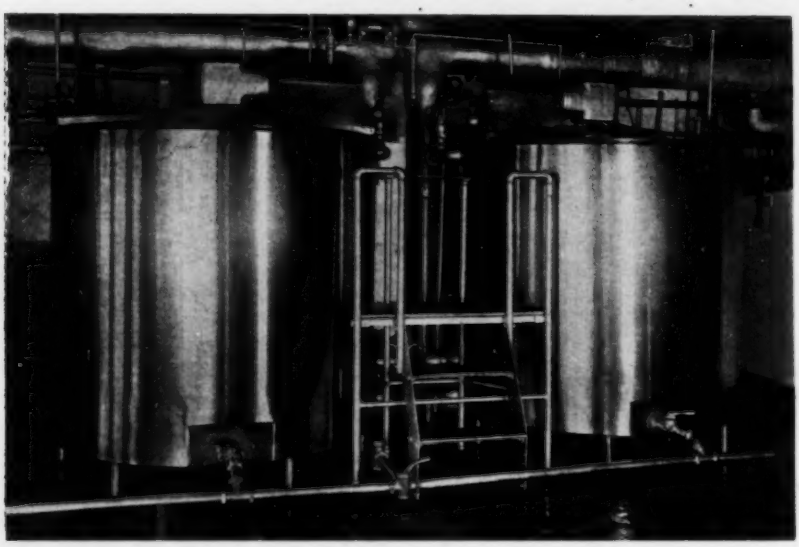

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VOLUME XXVII APRIL, 1944 NUMBER 4

LIVE WEIGHT AND MILK-ENERGY YIELD IN BRITISH GOATS

E. E. ORMISTON[1] AND W. L. GAINES

Illinois Agricultural Experiment Station, Urbana

The London Dairy Show, staged normally in mid-October each year, embraces a milch goat competition based on milk and fat yields for a two-day period. Records of these competitions are published in the Journal of the British Dairy Farmers' Association and include live weights of the individual goats at time of the contest, as well as various data of milk yield.

The present article deals with these two-day records (on a per-day basis) for the 17 years, 1920–1937 except 1927, and is particularly concerned with the size-yield relationship.

STAGE OF LACTATION

Since goats have a pronounced tendency to bear their young in the spring season they are usually rather far advanced in stage of lactation at time of the contest in October. For present purposes all records more than 360 days after kidding are rejected (14 records, 486 to 959 days after kidding). All other records are used, a total of 318 distributed as follows, with respect to 30-day month after kidding:

Month	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th	11th	12th
Number	1	5	5	14	28	38	85	98	40	1	2	1

Apparently kidding occurs most frequently in the month of March. The delayed stage of lactation must be kept in mind in considering the magnitude of yields. Assuming a linear lactation curve, the daily yield for the first 8 months of lactation would be somewhat greater than the daily yield for the contest period. Of course, what the yields represent is only the contest period, for the goats selected to enter the contest. Naturally a goat with too little persistency, that is, milking at too low a level at the time would not be entered.

AVERAGE PERFORMANCE BY BREEDS

Table 1 shows the average of the 318 records to be 8.36 pounds of milk and 0.390 pounds of fat per day at an average stage of lactation 195 days

Received for publication August 16, 1943.

[1] On leave of absence for military service.

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TABLE 1

Average data (daily basis) for goats by breeds, in order of live weight, W, at the London Dairy Show

Breed	n	Stage ds.	Fat %, raw	Fat %, weighted	Milk	Fat	FCM	W	100FCM/W*
					lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Toggenburg	22	185	4.08	4.09	7.33	0.300	7.44	130	5.71
Unidentified	106	185	4.86	4.76	6.51	0.309	7.25	134	5.46
Anglo Nubian Swiss	25	209	4.77	4.69	8.86	0.416	9.78	153	6.43
British Toggenburg	24	192	4.57	4.54	8.76	0.398	9.47	155	6.13
Saanen	17	213	4.72	4.66	8.48	0.395	9.31	163	5.80
Anglo Nubian	18	177	6.37	6.30	7.08	0.446	9.52	168	5.73
British Alpine	45	197	4.61	4.55	9.31	0.423	10.08	173	5.97
British	20	211	4.74	4.65	10.72	0.499	11.77	176	6.69
British Saanen	41	213	4.46	4.42	11.51	0.509	12.24	176	7.04
All breeds	318	195	4.76	4.66	8.36	0.390	9.19	154	5.99

* Averages of the individual 100FCM/W values.

after kidding. The average milk-energy yield, FCM, is 9.19 pounds of 4 per cent milk.[2] The average of the 318 fat percentages is 4.76 but when weighted by milk yield this becomes 4.66.

As between breeds considerable variation is shown. The breed class designated "unidentified" is largely composed of "just goats" but includes a few animals properly belonging in another class, where the breed identity could not be ascertained from the published record. The breeds are arranged in table 1 in order by average live weight. The larger size and greater productivity of the British strains (British Alpine, British, British Saanen) are conspicuous.

TABLE 2

Variance with respect to certain items, as between and as within certain groups— London Dairy Show goats. Live weight, W, in pounds; milk and FCM in pounds per day

Group	Item	Degrees of freedom		Variance		F	5% F	1% F
		Between	Within	Between	Within			
Breed	Live weight	8	309	13,289.0	643.0	20.67	1.97	2.57
"	Milk	"	"	123.1	4.4	27.78	"	"
"	FCM	"	"	128.9	5.5	23.37	"	"
"	100FCM/W	"	"	11.7	2.3	5.07	"	"
Age	Live weight	9	308	3,225.0	896.0	3.60	1.91	2.48
"	FCM	"	"	10.6	8.6	1.24	"	"
"	100FCM/W	"	"	5.2	2.5	2.08	"	"
Live weight	FCM	16	301	64.2	5.7	11.31	1.68	2.07
" "	100FCM/W	"	"	3.1	2.5	1.24	"	"

[2] FCM = 0.4 × milk + 15 × fat. One pound FCM = 340 kilocalories milk energy = 0.034 pounds milk protein regardless of the fat percentage of the natural milk. This relation is known to hold quite accurately in cows and is presumed to be applicable in goats.

LIVE WEIGHT AND YIELD

The variance data of table 2 show that the breeds are distinctly different with respect to live weight and FCM yield; less distinctly (although significantly in the statistical sense) with respect to FCM/W, that is, milk energy per unit live weight. Reference to table 1, column headed 100FCM/W, indicates the breed differences in FCM/W arise in a tendency for the larger breeds to produce more milk energy per unit live weight than the smaller breeds. Evidently the British strains are being developed for large size and milking proclivity; and milking capacity appears to be fully proportional to the larger size, as between breeds.

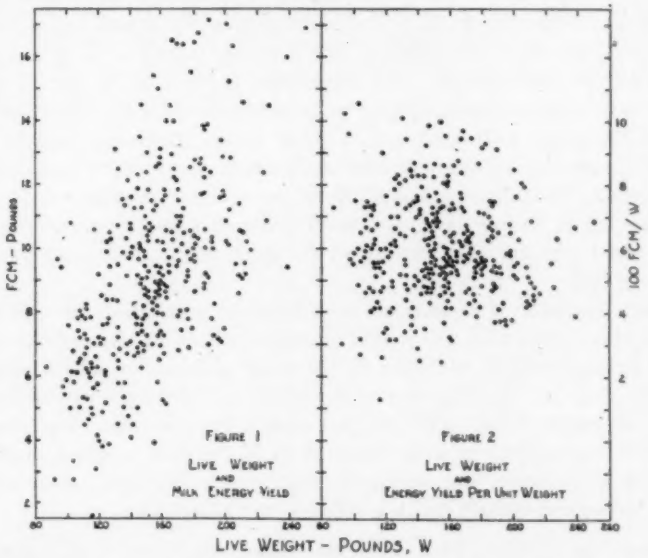
FCM - Pounds
100 FCM/W
FIGURE 1
LIVE WEIGHT AND MILK ENERGY YIELD
FIGURE 2
LIVE WEIGHT AND ENERGY YIELD PER UNIT WEIGHT
LIVE WEIGHT - POUNDS, W

FIG. 1, FCM, in pounds per day plotted against live weight in pounds for each of the 318 records.

FIG. 2, FCM, in pounds per day per 100 pounds live weight plotted against live weight in pounds, same records as figure 1.

Figure 1 shows each of the 318 FCM records plotted against live weight without regard to breed. FCM ranges from 1.5 to 17.2 pounds per day and live weight ranges from 88 to 250 pounds. There is a fairly close correlation between live weight and milk-energy yield, amounting to $r = 0.57$. If milk-energy yield is expressed as a power function of live weight, $FCM = aW^b$, it is found that $b = 0.91$. From table 1 if FCM is expressed as $FCM = aW^b$ it comes out that $b = 1.54$, as between breeds; and $b = 0.57$ as within breed.

Figure 2 shows each of the 318 FCM/W records plotted against live weight. If FCM is proportional to $W^{0.91}$ (figure 1) it should follow that FCM/W is proportional to $W^{-0.09}$, that is FCM/W decreases slightly with increasing W. Table 2 shows, however, that FCM/W variance as between live weight groups differs only slightly from the variance within live weight groups. In other words FCM/W appears to be independent of W in the 318 records taken as a whole.

DISCUSSION

There are some elements of uncertainty as to the broad meaning of the present size-yield data. The goats entered in the contest are a selected lot, to meet the competition which is predominantly one of points for production, viz.: 1 point per pound of milk plus 20 points per pound of fat plus 4 points per pound of solids-not-fat. No distinction is made as to size of animal except indirectly by distinguishing between first-kidders and older[3] animals. Since a 100-pound goat competes on a par with a 200-pound goat in terms of absolute yield it follows that selection must be more severe in the smaller size animals. This tends to bias FCM/W, as concerns an unselected population, making it unduly large for small goats and unduly small for large goats. Just how far this may affect the data of figure 2 (and figure 1) cannot be said.

What is needed is records on an unselected population for the first 8 months of lactation with live weight measured within 31 days after kidding. In the present records variation in the stage of lactation affects not only the daily yield for the 2-day period but affects also the numerical value of b in the regression, $FCM = aW^b$, at least such is true in cows. For example, in Holstein cows, dealing with 8-months FCM and live weight measured at 10 stages of lactation, viz., within the first month (31 days) after calving, within the second month, etc., b is affected as follows:

Month	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
b =	1.01	0.96	0.93	0.94	0.92	0.89	0.91	0.82	0.82	0.83

For the present goat data the average stage of lactation is within the 7th month after kidding and $b = 0.91$ which agrees with the 7th month in the Holstein data. By inference if live weight in the goats had been measured within 31 days after kidding we might expect to find $b = 1.01$.

Finally it may be noted that the average of the 318 records is 5.99 pounds FCM per day per 100 pounds live weight, 60 pounds per 1000 pounds live weight. This is perhaps nearly double what we should find in cows under comparable conditions. Metabolic tempo (metabolism per cell

[3] In table 2 it will be noted there is no significant difference between age classes with respect to either FCM or FCM/W. For these records age distinctions are wholly without importance, but live weight distinctions are very important.

per unit time) as between goats and cows follows a "$\frac{3}{4}$ power rule" with respect to live weight; but within species metabolic tempo is independent of live weight.

SUMMARY AND CONCLUSIONS

This article deals with 318 records of goats in two-day milking competition at the London Dairy show. The milk-energy yield, FCM, ranges from 1.5 to 17.2 pounds per day. Live weight, W, ranges from 88 to 250 pounds. The correlation between W and FCM is 0.57. In the power equation regression, $FCM = aW^b$, $b = 0.91$.

Attempting to bring the data into line with FCM for the first 8 months of lactation and live weight measured within 31 days after kidding it appears probable that b in the regression $FCM = aW^b$ may be safely taken at unity. That is, milk-energy yield in well-developed milch goats tends to be proportional to live weight.

FURTHER STUDIES ON OXIDATION OF VITAMIN A AND CAROTENE IN MILK FAT

VLADIMIR N. KRUKOVSKY
College of Agriculture, Cornell University, Ithaca, New York
G. H. ELLIS AND BARBARA W. BARNES
United States Nutrition Laboratory, Ithaca, New York

Our previous study (2) of the effect of storage temperature upon the rates of destruction of vitamin A and carotene in milk fat protected from the light but exposed to the air has indicated that following an induction period, simultaneous progressive destruction of vitamin A and carotene occurs in samples held at 40°, 50°, and 60° C. Since that time additional data have been obtained concerning the changes in vitamin A and carotene contents of the milk fat held at lower temperatures than its melting point; namely, the region within which under favorable conditions the fractional crystallization of glycerides takes place.

We also reported that the reconstitution test is very useful in recognizing the flavor defects of the milk fat and thus the extent of oxidative deterioration. This was evident from the fact that the milk made of pasteurized skimmilk and post-induction period fat developed off flavors, which continued to increase rapidly in their intensities instantaneously after processing, while the one containing fresh fat showed fairly good keeping quality. Subsequently it was observed that the latter milk at the end of 24 hours' storage at 5° C. developed off flavor, although of much lower intensity than the other but nevertheless identified by judges as slightly oily or tallowy and which lowered its score from 23 to 21 points, as compared with the score of zero for the first milk at the end of the same period.

Since the conditions for oxidation appear to be favorable, when fat is redispersed in skimmilk, we can assume that the above technique can be of value in readily detecting changes in the resistance of milk fat to oxidation, whether these changes are brought about during storage, by exposure to light, or any other factor.

For these studies the vitamin A and carotene contents of the fat were determined by the Koehn and Sherman method (3), while in the preparation of milk fat we followed the same procedure as described in the former paper (2).

EXPERIMENTAL

The Effect of Rapid Solidification of Milk Fat Upon the Rates of Destruction of Vitamin A and Carotene

In a study of the relationship between the temperature of storage and the rates of destruction of vitamin A and carotene in the milk fat (2), it was

Received for publication August 20, 1943.

pointed out that the samples of fat in the "liquid" state were placed in incubators at constant temperatures. At the end of the holding period at temperatures below the melting point, these samples were found to be well separated into solid crystalline and liquid fractions. It is apparent, therefore, that the system involved was quite different from the one represented by fat stored at higher temperatures.

The additional data concerning this particular experiment are presented in figure 1. They show that at higher temperatures vitamin A and carotene are destroyed at approximately the same rate, whereas at lower temperatures vitamin A is destroyed more rapidly.

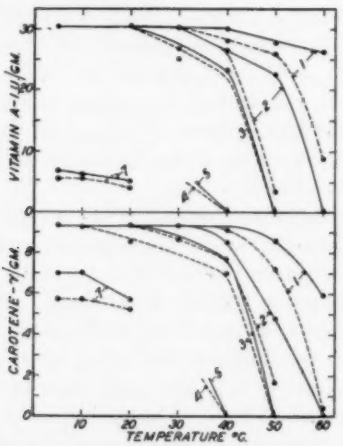

FIG. 1. The relation between the temperature of storage and the rates of destruction of vitamin A and carotene in the fat from (1) milk (solid line) in which lipolysis was checked by pasteurization immediately after excretion by mammary gland, and (2) milk (dotted line) in which lipolysis was accelerated. The fat was exposed to the air but protected from the light. Numbers 1–7 on the graphs indicate months of storage.

There are no significant differences in the rates of destruction between the samples held at 5°, 10°, and 20° C., or between the fats isolated from normal and rancid milks.

In order to learn if the physical state of the fat at the time of storage was a factor governing the rates of destruction of vitamin A and carotene, 25 grams of fat were weighed into half-pint milk bottles, to provide a sufficient surface contact between the fat and outside air. Several of these samples were held first at – 14° C. for a period of time to insure a rapid solidification of the fat and then stored at 5° and 20° C. The remaining samples while still in a liquid state were placed at the same temperatures.

The data are presented in table 1. It is apparent that rapid precooling of fat retards the destruction of vitamin A and carotene during the storage at both 5° and 20° C.

TABLE 1

The effect of solidification of milk fat upon its vitamin A and carotene

Fat from normal pasteurized milk

Physical state previous to storage	Stored at temperature	Vitamin A	Carotene
	°C.	*I.U./gm.*	*γ/gm.*
S.	5	21.1	4.3
L.	5	13.6	3.5
S.	20	18.4	4.2
L.	20	11.0	3.8

The samples were analyzed at the end of seven months' storage in the dark. Symbols indicate: S.—solid, and L.—liquid, fats, respectively.

The physical states of these samples at the end of storage were quite different. The samples which were cooled rapidly at – 14° C. remained firm, retaining their homogeneous fine texture; the others had a coarse spongy semi-solid texture. Since atmospheric oxygen plays an important part in oxidative deterioration of milk fat protected from the light, it is possible to assume that the destruction of vitamin A and carotene might be traced in part to the rates of diffusion of atmospheric oxygen into the samples.

The keeping quality of different solid fats might vary with their degree of hardness, a factor determining the rate of crystallization.

These results suggest that a functional relationship exists between the

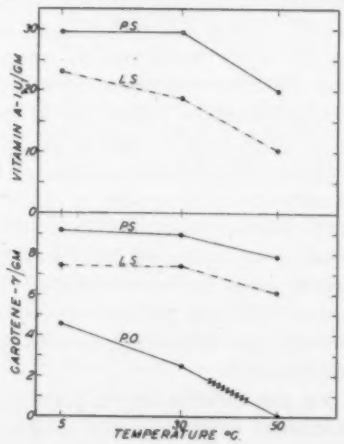

FIG. 2. The vitamin A and carotene contents of samples of milk fat in tightly sealed (S.) or open (O.), plain (P.) and lacquered (L.) tin cans after seven months' storage at indicated temperatures. In plain open tin can (P.O.) the sample was colorless at the end of two and one-half months of storage at 50° C. In the open lacquered cans the samples were all colorless at the end of seven months of storage.

rates of influx of atmospheric oxygen on one hand and the rates of destruction of vitamin A and carotene on the other.

In order to test this possibility, samples of fat in tightly sealed or open tin cans, both lacquered[1] and plain, were placed while still in the liquid state at temperatures of approximately 5°, 30°, and 50° C. These cans were filled to the top. The vitamin A and carotene contents of the tightly sealed samples were determined after storing for 7 months, while carotene only was determined in the other samples.

The data presented in figure 2 show that in the absence of free surface contact with atmospheric oxygen the destruction of vitamin A and carotene proceeds at a much slower rate or not at all, depending upon the temperature of storage and the type of container used.

It seems probable, therefore, that in absence of light, only when fat is exposed to atmospheric oxygen is its physical state a factor governing the rates of destruction of vitamin A and carotene. Subsequently, it was found that the induction period of fat could be considerably prolonged by covering the exposed surface with a sheet of tin foil to exclude the air.

The Destruction of Vitamin A and Carotene Resulting from Reemulsification of Milk Fat in Pasteurized Skimmilk

Preliminary work has been done to show the extent to which vitamin A and carotene of the milk fat is reduced by reemulsification in skimmilk and some of the factors involved in this phenomenon.

In a previous paper (2) it was shown that at the point when the vitamin A content of fat exposed to light generated by a mercury vapor lamp was reduced to a minimum, the concentration of its precursor remained practically unchanged. The data in figure 3 show that at the end of 30 minutes of exposure the vitamin A drops from a value of 33 I.U./gm. to 4.5 I.U./gm. Irradiation for an additional 90 minutes causes no further drop in vitamin A. It did not seem reasonable to us that part of the vitamin A would resist destruction, so it may be assumed that the value of 4.5 I.U./gm. is due to an artifact. That this is so, is supported by the observation that no absorption peak in the 620 mμ region of the spectrum could be detected with the Beckmann spectrophotometer following the Carr-Price reaction, nor could an absorption peak be found in the 326 mμ region with the unsaponifiable fraction dissolved in diethyl ether.

It was found (2) that atmospheric oxygen plays an important part in the photochemical destruction of carotene, while in the case of vitamin A an additional photochemical reaction caused its rapid destruction. Therefore, it seemed of interest to learn if the exposure of fat to light, prior to its reemulsification in pasteurized skimmilk, renders carotene more susceptible to oxidation.

[1] Sanitary enamel.

For this reason the irradiation experiment was repeated following the same procedure as previously described, with the exception that the temperature of fat was maintained at 50° C. and the intensity of the mercury vapor lamp at 19,000 foot candles.[2] The samples were irradiated for various periods of time up to 120 minutes. At the end of each period they were divided into two parts. One part was immediately analyzed for vitamin A and carotene, while the other one was reemulsified[3] in pasteurized skimmilk, then held for 24 hours before separation and analysis.

The data are presented in figure 3. Although the carotene content of the samples was not altered by irradiation, its susceptibility to oxidation in the

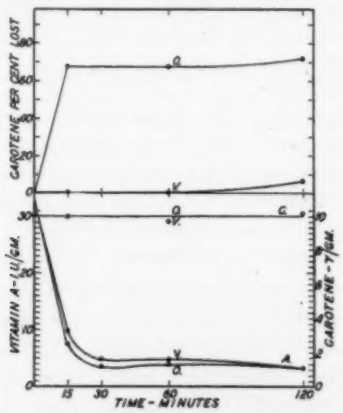

FIG. 3. The effects of irradiation and of reemulsification of irradiated milk fat in pasteurized skimmilk upon vitamin A and carotene. The effect of irradiation alone is shown in the lower chart. The upper chart shows the losses in carotene (per cent) due to reemulsification of fat. Symbols on the graphs indicate: C—carotene, A—vitamin A, O. and V.—fat irradiated in open or under vacuum sealed tubes.

presence of skimmilk was definitely affected when the fat was irradiated in open tubes. In this case 70 per cent of the carotene was lost due to the reemulsification of fat in pasteurized skimmilk, whereas the fat which was irradiated in vacuum sealed tubes was not affected.

Subsequently it was thought worth while to obtain some idea concerning the destruction of vitamin A and carotene produced by irradiation, such as might be encountered under ordinary conditions.

Samples of fat in 18-mm. test tubes filled to the top and left open were irradiated for 10 hours with northern daylight passing through window glass.[4] (This sample had been stored for 4 months at 5° C. in the dark.)

[2] Weston light meter.

[3] In Club aluminum cream maker.

[4] The per cent transmission of incident light (Beckmann spectrophotometer) of this glass was as follows: 360 mμ—75.3%; 340 mμ—42.0%; 330 mμ—16.5%; 325 mμ—7.0%; 320 mμ—2.0%; 310 mμ—0%.

TABLE 2

The effect of irradiation with daylight upon vitamin A and carotene of milk fat

Milk fat

Irradiated with daylight		Reemulsif. in pasteur. skimmilk	Vitamin A	Carotene
Hrs.	*In*		*I.U./gm.*	*γ/gm.*
U.	.....	Before	19.4	9.6
U.	.....	After	11.0	9.2
10	O.T.	Before	6.0	8.3
10	O.T.	After	5.1	1.8
U.	.....	Before	29.5	9.0
U.	.....	After	12.3	7.8
8	P.D.	Before	12.3	7.4

O.T.—open tube, P.D.—Petri dish, U.—unirradiated control.

The light intensity throughout the duration of exposure varied from 200 to 400 foot candles as measured by a Weston light meter. Immediately after, a portion of this fat and one of the control samples were reemulsified separately in pasteurized skimmilk to produce a reconstituted milk containing 5 per cent fat. They were reseparated after holding for 24 hours at 5° C. These samples and the remaining portions were then analyzed for vitamin A and carotene. In another experiment a sample of fat in a covered Petri dish filled to the top was exposed for 8 hours only. (This sample had been stored for 7 months at 5° C. in a tightly sealed plain tin can.)

The data are presented in table 2. These results are in substantial agreement with the preceding observations.

A study of absorption spectra and chromatograms of carotene from irradiated and non-irradiated milk fat samples indicate that no change in the carotene occurred. The irradiation was carried out as previously described in 18-mm. test tubes by northern daylight. This indicates that the effect of irradiation is upon constituents of the fat other than carotene.

Finally the data of table 3 show the effect of irradiation with northern daylight upon vitamin A and carotene of fresh milk fat. To part of the

TABLE 3

The effect of irradiation with daylight upon vitamin A and carotene of fresh milk fat

Milk fat

Irradiated with daylight		Reemulsif. in pasteur. skimmilk	Vitamin A		Carotene
			Original	Original and added	
Hrs.	*In*		*I.U./gm.*	*I.U./gm.*	*γ/gm.*
U.	.....	Before	22.1	250.0	5.1
U.	.....	After	19.3	246.0	4.7
8	O.T.	Before	21.7	221.0	5.0
8	O.T.	After	17.0	163.0	3.9

O.T.—open tube, U.—unirradiated control.

sample crystalline vitamin A was added so that it contained 250 I.U. of vitamin A per gram of fat. Both samples of fat in 18-mm. test tubes were irradiated for 8 hours. The light intensity throughout the duration of exposure was less than 200 foot candles.

The results of this experiment were practically the same as the others, except that the losses in vitamin A produced by reemulsification of fresh unexposed fat in pasteurized skimmilk were rather small.

These observations appeared to be of a practical importance since they show that considerable losses in vitamin A, accompanied by the development of oily flavor, occur in the fat exposed to light, thus affecting not only the nutritive value of the product but its palatability as well.

Finally it should be noted that the destruction of vitamin A in the milk fat was accompanied by the development of oily flavor, whereas that of carotene was accompanied by the development of tallowy flavor (1, 2).

The data suggest that a relationship exists between the ability of fat to resist oxidation and the stability of carotene. It is possible that a partial or complete destruction of antioxidant renders fat more susceptible to oxidation, thus indirectly affecting carotene.

CONCLUSIONS

The present study shows that the resistance of both vitamin A and carotene to oxidation by redispersing the fat in pasteurized skimmilk decreases upon exposure of fat to light or after its prolonged storage in the dark.

Milk fat can be stored for several months even at 60° C. without loss of vitamin A or carotene providing the fat is degasified then placed in light-proof containers filled to the top and tightly sealed.

Rapid precooling as compared with slow cooling of milk fat retards the destruction of vitamin A and carotene during its storage at both 5° and 20° C. in open-to-the-air but protected-from-the-light containers.

The data indicate that milk fat containing free fatty acids shows more rapid loss of vitamin A and carotene during its storage at 40°–50° C. in open-to-the-air but protected-from-the-light containers.

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ZINC IN COWS' MILK*

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INTRODUCTION

References in the literature to the zinc content of cows' milk are rather infrequent. Several investigators report its presence in the spectrographic analysis of milk ash (3, 6, 7, 11, and 12), but only three report quantitative determination of the amount present (2, 4, and 8). Information on the influence of the amount of zinc in the feed on the zinc content of milk is practically negligible. Wright and Papish (11) in 1929 found more than the usual amount of zinc in milk obtained from cows pasturing in the neighborhood of a zinc smelter. Broek and Wolff (5) in 1935 found no marked variations in this element that could be attributed to feeding practice.

As part of a comprehensive project on the minerals of cows' milk, the effect of feeding zinc oxide on the zinc content of milk was investigated at this station during the past winter (1942–43).

EXPERIMENTAL

The procedure was similar to that followed in earlier work on manganese (1). Eight cows were divided into two groups of four each, with an Ayrshire, a Guernsey, a Holstein, and a milking Shorthorn in each group. The breed pairs were matched as closely as possible with regard to stage of lactation, none of the cows being beyond the 10th week in lactation when the work was begun. One group received the supplement during November, December and January; the other group received it during February, March and April. The amount of zinc oxide fed was ten grams daily mixed with the grain allowance. No ill effects were evident as a result of feeding this amount of zinc. Except for the feeding of the supplement the rations and management of the two groups were in all respects identical.

Composite two-day milk samples of one liter each were taken from each cow once a month. Zinc was determined in triplicate 200 ml. portions of each sample by the turbidity method of Bodansky (4) as quoted by Scott (10). As some slight modifications were introduced, the detailed procedure is given below.

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[1] Acknowledgment is made to Vernon C. Cole, who did the analytical work under the author's direction.

Method for Determination of Zinc in Milk

Solutions required: *Standard zinc* solution. Dissolve 0.1 gram of zinc (C.P.) in 10 ml. of HCl (sp. gr. 1.20); Dilute to one liter. 1 ml. = 0.0001 gram of zinc.

Citric acid solution—50%
Ammonium thiocyanate solution—2%
Potassium ferrocyanide solution—2%
Sulphuric acid—1 in 3.
Hydrochloric acid—1 in 5.

Procedure. Measure out 200 ml. of milk into a glazed silica evaporating dish and evaporate to crispness on a steam bath. Ash in an electric muffle furnace at just below perceptible redness; the dishes are placed in the cold furnace and the temperature is raised gradually to avoid frothing and spattering. The ash should be white or with not more than a tinge of gray. Cool and dissolve the ash with 25 ml. conc. HCl and 10 ml. conc. HNO_3; boil moderately on a hot plate for half an hour. Add 10 ml. of H_2SO_4 (1 in 3) and evaporate to dryness on a steam bath. Dissolve the residue in water and adjust the acidity to contain about 5 per cent H_2SO_4 (probable volume 150 cc.) and precipitate the heavy metals by bubbling H_2S through the liquid for an hour.

Filter off the heavy metals and boil the filtrate on a hot plate to remove H_2S; cool, add two drops of methyl red, neutralize with NH_4OH and add 10 ml. of a 50 per cent citric acid solution. Heat to boiling on a hot plate (watch out for bumping at this point) and if no calcium citrate separates add small quantities of calcium carbonate at a time until a precipitate of about one gram of calcium citrate is formed. Remove from heat and while still very hot pass a stream of H_2S through the solution until cool and for four hours thereafter. Filter through a small paper and wash with a 2 per cent solution of ammonium thiocyanate. Dissolve the precipitate in 25 ml. of HCl (1 in 5) heated almost to boiling, wash the paper with water, cool the filtrate and make up to 50 ml.

Place a 25-ml. aliquot of the filtrate in a 50-ml. Nessler tube and hold until a series of standards of appropriate range has been prepared by measuring portions of the standard zinc solution into other 50-ml. Nessler tubes. Dilute the standard and unknown solutions to about 40 ml. and add 3 ml. of HCl (sp. gr. 1.20) to the standards, and 2 ml. of 2 per cent potassium ferrocyanide solution to all the tubes. Dilute the contents of each tube to the mark and mix thoroughly. After two or three minutes compare the turbidity of standards and unknown in a suitable comparator rack with a white tile base and illuminated by fluorescent light. Calculate the percentage of zinc from the quantity of sample taken and the standard solution similar in turbidity to that of the sample. Standards used in this work were 2, 3, 4, 5, 6, 7, and 8 ml. of the standard zinc solution per 50 ml. of final volume. The method is sufficiently sensitive to permit matching to one-half ml. of the standard (0.00005 gram of Zn).

TABLE 1

Effect on zinc content of the milk of feeding cows zinc oxide (winter of 1942–43). Milligrams of zinc per liter of milk

Month	Cows receiving supplemental Zn					Cows on control ration				
	1st half of the season									
	A291	G626	H521	S38	Average all four	A320	G632*	H539	S62	Average all four
November	3.8	7.2	5.7	5.7	5.6	3.4	5.3	3.4	1.9	3.5
December	6.3	7.2	4.3	6.7	6.1	5.8	3.9	4.3	5.3	4.8
January	4.3	6.7	4.3	3.8	4.8	3.4	4.3	3.4	2.8	3.5
Average 1st half	.....	.....	.....	.....	5.5	.....	.....	.....	.....	3.9
	2nd half of the season									
	A320	G605	H539	S62	Average all four	A291	G626	H521	S38	Average all four
February	6.3	3.4	3.8	4.8	4.6	4.3	3.4	1.9	5.3	3.7
March	4.8	3.4	5.3	4.8	4.6	2.9	3.4	2.4	3.8	3.1
April	4.3	3.8	3.8	6.7	4.7	3.4	4.8	3.4	4.3	4.0
Average 2nd half	.....	.....	.....	.....	4.6	.....	.....	.....	.....	3.6
Average entire season	.....	.....	.....	.....	5.1	.....	.....	.....	.....	3.8

* Through a misunderstanding this cow was sold soon after the December samples were taken—G605 was substituted for her so that the values for January to April inclusive are for 605.

NOTE.—The initial letter prefixed to each cow's number indicates the breed.

RESULTS

The values obtained are set forth in table 1. The difference of 1.3 mgs. per liter in the zinc content of the milks from the two groups is statistically significant. A smaller difference was noted in the second half of the season than in the first, but this also is significant. It is believed that the difference between the groups in the second half would have been greater if Cow G632 had been retained in the herd. Rather consistently low values for zinc were obtained from analysis of the milk samples from the substitute Cow G605. Her milk also had a consistently low total ash content for a Guernsey (an average of 0.68% for the four months she was in the group as compared with 0.74% for her breed mate, G626, for the same four months). Also her milk looked abnormal, suggesting the high color of colostrum, although not above 4.7% fat at any time during the whole four months and running as low as 4% in March and April.

It is definitely suspected, therefore, that here was an abnormal milk, and if in consequence it be eliminated, the difference in zinc content of the milks in the second half of the trial is raised to about the same magnitude as it was in the first half, *i.e.*, approximately 1½ mgms. per liter more zinc in the milk when the cows were fed zinc oxide than when they were not.

In agreement with the work of Birckner (2) considerable individual variation is noted in the amounts of zinc from the different cows, but it should be observed that out of twenty-four comparisons, zinc was higher in the milk from the control group in only two instances and in one of these two the apparently abnormal milk already referred to was involved.

The amounts of zinc in the control samples are in good agreement with those reported by Birckner (2) and by Sato and Murata (9).

SUMMARY

Zinc oxide was fed as a supplement (10 grams per cow daily) to the ration of eight cows for a period of three months by the double reversal method. The milks from the cows were analyzed for their zinc content and it was found that feeding the zinc supplement had consistently raised the level of that element in the milk, the average being 5.1 mgms. of zinc per liter of milk as contrasted with an average of 3.9 mgms. when the cows were on a control ration.

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THE DIGESTIBILITY OF KOREAN LESPEDEZA HAY AND GROUND KOREAN LESPEDEZA SEED FOR DAIRY HEIFERS*

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Korean lespedeza is playing an increasingly large part in the feeding program of farm animals. It is widely used as a fine mid-summer pasture crop and as hay; and the abundant yield of seed can be utilized as a high protein concentrate for livestock feeding. Although the high feeding value of Korean lespedeza has been shown often in comparative feeding trials, few reports have appeared concerning the digestibility of the hay fed alone. The investigation reported herein was therefore instituted for the purpose of determining the digestibility of different types of Korean lespedeza hays and the digestibility of Korean lespedeza seed fed with different hays.

MATERIALS AND METHODS

Three lots of Korean lespedeza hay were used. Each was grown on a different farm near Columbia, Missouri. The fertility of the soil on which each was grown was only fair. The fields had been clipped while the lespedeza was small so that the hays were practically pure lespedeza. One lot, secured in 1941, was cut about two weeks previous to the start of blooming. In 1942 one lot was made just as blossoms were starting to appear and a second lot was made when blooming was over and the seeds were mostly in the dough stage. The alfalfa hay was third-cutting Missouri-grown hay of good quality.

The Korean lespedeza seed was cleaned seed secured on the open market.

Holstein-Friesian heifers 18 to 20 months old were used as experimental animals. The digestibility of each ration was determined with four heifers. Collection periods were of 10 days duration following a 10-day preliminary feeding period in which a constant daily amount (16 pounds) of the ration was fed.

The hays were chopped in a hammermill using a 1-inch screen. The seed was twice ground through a $\frac{3}{8}$-inch screen of the hammermill. The entire amount of hay or hay and seed to be fed was thoroughly mixed and sacked into daily rations previous to starting the trials. At the time of sacking the feeds were sampled for moisture determination. The composition of the feeds was determined from composite samples representing the entire lot. The lespedeza hay and seed rations were composed of 1 part seed and 3 parts hay. Four parts of alfalfa hay were used per part of seed.

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TABLE 1

Average composition of feeds used in digestion trials and of feces, dry basis

	Crude protein	Ether extract	Ash	Crude fiber	Nitrogen-free extract	Lignin	Cellulose	Other carbohydrates
	%	%	%	%	%	%	%	%
(1) 1941 lespedeza hay (early)	12.42	3.16	5.33	32.17	46.92	15.93	30.96	32.20
(2) 1942 lespedeza hay (intermed.)	11.84	2.37	5.48	34.09	46.22	19.97	34.50	25.84
(3) 1942 lespedeza hay (late)	13.28	2.76	5.45	37.02	41.49	23.14	33.13	22.24
(4) 1942 alfalfa hay	16.94	1.95	10.07	32.82	38.21	11.42	33.86	25.75
(5) 1941 lespedeza seed	36.39	9.95	5.80	10.28	37.58	5.67	13.29	28.89
(6) 1942 lespedeza seed	39.42	5.67	6.21	13.88	34.83	10.33	15.39	22.98
(7) Lespedeza seed + early hay	18.58	4.91	5.44	26.55	44.52	13.29	26.43	31.36
(8) Lespedeza seed + late hay	20.02	3.51	5.65	31.06	39.76	19.83	28.50	22.49
(9) Lespedeza seed + alfalfa	21.61	2.73	9.27	28.88	37.51	11.20	30.02	25.17
Feces from (1)	14.40	5.33	10.50	35.08	34.68	31.08	27.13	11.55
Feces from (2)	13.28	4.30	9.90	32.67	39.85	34.88	27.46	10.18
Feces from (3)	13.86	4.39	9.38	32.78	39.59	36.58	25.58	10.21
Feces from (4)	14.14	4.49	14.32	37.30	29.76	25.66	29.06	12.33
Feces from (7)	15.63	6.62	15.83	30.33	31.59	28.66	25.15	8.11
Feces from (8)	15.44	5.33	9.67	32.74	36.82	34.01	26.03	9.52
Feces from (9)	15.00	5.42	13.14	34.21	32.23	27.51	28.81	10.12

The feces were collected by an automatic separator patterned after an apparatus described by Ritzman and Benedict (7). A 3 per cent aliquot sample was taken from each day's fecal output from each heifer. The daily samples were composited, moistened with 2 per cent hydrochloric acid, and stored in a refrigerator at 5° C. until the completion of the collection period. The feces were then thoroughly mixed, dried with stirring in a Freas electric drying oven at 50° C., allowed to reach weight equilibrium in the laboratory, ground in a Wiley mill, and sampled for analysis.

Analyses were made of the feeds and feces by methods prescribed by the A.O.A.C. (2) for nitrogen, ether extract, crude fiber, ash, and nitrogen-free extract. Moisture was determined by drying in a drying oven at 105° C. until weighings at 2-hour intervals showed no further loss. Lignin, cellulose, and other carbohydrates were determined according to the method of Crampton and Maynard (3) except that the ether-extracted sample was moistened and autoclaved previous to digestion with 0.5 per cent pepsin in N/10 hydrochloric acid.

Digestion coefficients, total digestible nutrients, and nutritive ratios have been determined in the usual manner.

RESULTS AND DISCUSSION

The composition of the feeds and rations fed and the average composition of the feces from each ration are listed in table 1 on the dry basis. These show that lespedeza hay does not decrease in protein content with advancing maturity but that lignification is quite marked as the plant matures. The high protein content of lespedeza seed is demonstrated. The seed also has a sizeable portion of fiber due to the hulls which normally adhere tightly to the seed.

The average digestion coefficients, total digestible nutrients, and nutritive ratios which were calculated for the different rations and feeds are presented in table 2.

The effect of advanced maturity upon the nutritive value of Korean lespedeza hay is clearly shown in table 2. With increased maturity there was a decrease in digestibility of practically every nutrient division. While lespedeza hay cut well in advance of bloom was very acceptable as a source of total digestible nutrients, late cut hay was markedly inferior. It is also worthy of note that the nutritive ratio of the good lespedeza used here was much wider than the 1:4.7 estimated by Morrison (6). This is due to the fact that the protein of Korean lespedeza hay is not digested as thoroughly as that from many other legumes. The high lignin content of lespedeza leaves has been proposed by Swanson and Herman (9) as an explanation of the poorer protein digestion from lespedeza hay.

The data in table 2 also present further evidence of the importance of the lignin content of the feed to its utilization. There is a remarkably close

TABLE 2

Digestion coefficients, total digestible nutrients, and nutritive ratios of Korean lespedeza hay and seed

	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract	Lignin	Cellulose	Other carbohydrates	Total dry matter	Total dig. nutr. (dry basis)	Nutritive ratio 1:
	%	%	%	%	%	%	%	%	%	
1941 lespedeza hay (early)	49.17	29.15	54.21	68.90	17.99	63.18	84.91	57.95	57.95	8.48
1942 lespedeza hay (intermed.)	42.51	7.06	50.82	55.78	10.40	59.16	79.79	48.70	48.51	8.64
1942 lespedeza hay (late)	41.03	10.18	49.92	46.03	10.60	56.34	74.01	43.44	43.66	7.01
1942 alfalfa hay	65.10	5.00	52.42	67.47	5.99	64.09	79.96	58.17	54.23	3.92
Lespedeza seed + early hay	63.51	41.49	50.41	69.26	6.62	58.69	88.76	56.64	60.59	4.13
Lespedeza seed + late hay	61.70	24.59	47.57	53.99	14.80	54.58	78.87	50.29	50.54	3.09
Lespedeza seed + alfalfa hay	72.52	21.34	53.11	65.96	3.00	61.99	84.06	60.39	57.06	2.64
Lespedeza seed (− early hay)	77.66	52.85	20.82	70.56	0	27.39	94.94	52.86	68.76	1.43
Lespedeza seed (− late hay)	81.74	44.86	30.28	81.29	41.90	43.52	90.13	70.01	70.45	1.19
Lespedeza seed (− alfalfa)	84.66	42.66	59.33	59.67	1.85	44.45	97.84	68.87	67.83	1.03
Average of all lespedeza seed	81.35	46.79	36.81	70.51	14.58	38.45	94.30	63.91	69.01	1.22

relationship between the lignin content and the digestibility of the three lots of lespedeza hay. The lignin-digestibility relationship does not seem the same for the alfalfa hay as for the lespedeza hay, however. This may be due to the fact that the heifers did not ruminate on the alfalfa rations, presumably because it was ground too fine, but did ruminate on all of the lespedeza hay rations. This lack of rumination may have slightly depressed the digestibility of the alfalfa hay. Ritzman and Benedict (8) found that ground alfalfa hay was less digestible than unground hay. It is also probable that the type and manner of deposition of lignin is so different in alfalfa and lespedeza that their relative amounts are not an adequate measure of their effect upon digestibility of the two kinds of hay.

A few seeds from the late-cut lespedeza hay came through the heifers whole. This loss of nutrients may have accounted for part of the low digestibility of the late-cut hay. The undigested seeds were not in great numbers, however, and it is believed that their effect upon lowering the digestibility of the hay was of minor importance compared to the effect of the high degree of lignification of the plant.

In drawing conclusions about the effect of maturity upon the digestibility of Korean lespedeza hay from these data, one must consider that the three lots of hay came from three different farms and were grown in two different seasons. Hays of different maturity from the same field grown in the same season may show slightly different variations than are shown in table 2.

The digestibility of Korean lespedeza seed was determined with three lots of hay, early-cut lespedeza hay, late-cut lespedeza hay, and alfalfa hay. The average results of the trials with each hay and the average of all of the lespedeza seed digestibility calculations are presented in table 2. It is shown there that the crude protein and the non-fibrous carbohydrate of lespedeza seed are quite highly digestible. Great variation was found in the digestibility of the fibrous portion of the seed. The seed was moderately high in total digestible nutrients, 69.01 per cent on a dry basis, and furnished a large amount of digestible protein, the average nutritive ratio being 1: 1.22. The differences in digestibility of the seed fed with the different hays were not of noteworthy importance when it is considered that two different lots of seed were used. The 1941 seed was higher in ether extract and its ether extract was digested better than that of the 1942 seed.

Many analyses of lespedeza seed at the Missouri station have shown that it contains approximately 35 to 40 per cent total crude protein. This would be equivalent to about 28.5 to 32.5 per cent digestible crude protein. The ground lespedeza seed was eaten with relish by every one of the eight heifers used. It did not appear to exert any abnormal effect upon the animals. Experiments by Herman and Ragsdale (4), Irwin and Kempster (5), and the Missouri Department of Animal Husbandry (1) have shown that Korean lespedeza seed serves satisfactorily in rations of dairy cattle, beef cattle,

poultry, and sheep. It should therefore be considered as a very nutritious high protein concentrate which well deserves the attention of farmers seeking to increase their supply of home-grown high protein feeds.

SUMMARY

Digestion coefficients were determined on Korean lespedeza hay cut well in advance of bloom, just before bloom, and after bloom. The digestibility of practically all nutrients was decreased with advanced maturity and the late-cut hay was a very poor source of total digestible nutrients. The lignin content of the hays increased with maturity and as the lignin increased digestibility was decreased.

Digestion coefficients were calculated for ground Korean lespedeza seed fed with two types of lespedeza hay and with alfalfa hay. The lespedeza seed crude protein averaged 81.35 per cent digestible which makes the seed contain approximately 28.5 to 32.5 per cent digestible crude protein. The seed contained an average of 69.01 per cent total digestible nutrients and had a nutritive ratio of 1 : 1.22.

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CITRUS MOLASSES—A NEW FEED*

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Citrus molasses was produced in Florida on a commercial scale during the canning season of 1941–1942 with a production of 2500 tons. During 1942–1943 this was increased to about 4700 tons. Approximately one-half of domestic blackstrap molasses was unavailable for feeding purposes due to its retention for manufacture of war materials. Hence citrus molasses filled a need in the manufacture of mixed feeds. The supply of citrus molasses has been insufficient to meet the demand of the mixed feed industry.

RECOVERY OF CITRUS MOLASSES

From a survey made by the Department of Agricultural Economics of the Florida station it was determined that 67.5 per cent of bulk citrus fruits remains as peel, rag, and seed, from the canning of hearts, juice, and citrus concentrate. This residue or fresh pulp contains about 85 per cent of moisture mostly as bound water, or water of constitution.

Addition of calcium salts to the fresh pulp liberates the bound water. One-half of the water then is removed by pressure. The pulp is dehydrated into dried citrus pulp. The press juice contains about 5.4 per cent solids—mainly sugars. Evaporation of this material under partial vacuum to about one-thirteenth of the original volume results in a light colored sweet viscous syrup known to the feed industry as "citrus molasses." A glucoside—naringin—which imparts a characteristic flavor to citrus peel, also is concentrated in the process, so that its flavor is accentuated in the molasses.

COMPOSITION OF CITRUS MOLASSES

Citrus molasses is not wholly standardized as to composition perhaps due to changes in the press juice from citrus fruits as the season advances. The producers concentrate it to a reading of 75 degrees Brix. The resulting product varies slightly in total solids content, and in proportions of the different constituents.

Four analyses of citrus molasses are available, 3 from the 1941–1942 crop, and one (Sample No. 4) determined in the Nutrition Laboratory from the 1942–1943 crop. These analyses are given in table 1.

The specific gravity of citrus molasses (Sample No. 4 was 1.376) and a pH value of 4.65 was observed. Analyses showed 0.94 per cent of calcium citrate [$Ca_3(C_6H_5O_7)$] present as fine white flakes which settled out on

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TABLE 1

Analyses of citrus molasses

Sample No.	Dry matter	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract	Ash	Reducing sugars	Non-reducing sugars	Weight per gallon
	%	%	%	%	%	%	%	%	*lbs.*
1	66.8	5.00	0.15	None	57.97	3.57	20.92	19.87	11.07
2	71.2	3.86	0.24	0.03	61.76	5.31	27.74	15.28	11.61
3	75.2	3.75	0.23	None	65.95	5.24	32.00	18.70	.....
4	66.5	3.39	None	None	59.64	3.47	.....	.....	11.17

standing. The major constituents of this molasses are reducing and non-reducing sugars, the proportions of which vary. No fiber is present. The amount of ether extract depends upon the mechanical separation, or the evaporation of citrus oils.

No digestion trials have been conducted using citrus molasses. Digestion trials on similar products included 4 with beet molasses and 26 with cane or blackstrap molasses, cited by F. B. Morrison in "Feeds and Feeding," 20th edition. The weighted average of these digestion coefficients—35 per cent for crude protein and 90.1 per cent for nitrogen-free extract—applied to the average crude protein and nitrogen-free extract from analyses of citrus molasses in table 1, gave an estimated value of 1.4 per cent digestible crude protein and 56.7 per cent of total digestible nutrients, with 69.9 per cent of dry matter in the molasses.

PALATABILITY OF CITRUS MOLASSES

Since the flavor of naringin predominates in citrus molasses, the palatability of the product for dairy cows was questioned. Two brief conclusive palatability trials were conducted with the Jersey cows in the Experiment Station dairy herd using different levels of molasses. Since a 9 per cent level of blackstrap (sugarcane) molasses is the amount present in many commercially mixed dairy feeds five per cent of citrus molasses was incorporated into home-mixed concentrates. Twenty-five cows were offered 2 pounds each of the molasses-concentrates after consuming their regular afternoon allowance of feed. All of the feed was consumed without hesitation. On the second day, 10 pounds of citrus molasses were incorporated with 90 pounds of concentrates; offered in the same manner, and consumed completely by the 25 animals.

Thirty-four Jersey and Guernsey cows were offered straight citrus molasses from one to three times while in the stanchions. Twenty-six animals refused it on first offering, 17 on the second, and 8 on the third offering. Eleven cows ate all of the citrus molasses; 7 took part; 5 tasted it, and three others ate all when mixed feed was sprinkled beside it. When offered first, the majority of cows did not care for the pure product, the proportion decreasing on later offerings. It is believed that cows would learn to take this feed, but it appears undesirable for feeding separately.

EFFECT ON MILK FLAVOR

Does citrus molasses affect the flavor of milk? To answer this question individual milk samples were obtained from four Jersey cows after being in dry lot 10 hours without feed. On other days, citrus molasses was added as 10 per cent of the mixed concentrates, fed 2 hours prior to milking time, and additional milk samples obtained. Samples from the complete milking were collected in milk bottles, cooled immediately in ice water and held at 35° F.

TABLE 2

*Effect of citrus molasses on the flavor of milk, as scored by 3 judges**

	Cow No.				Average
	664	655	708	737	
Cows received no feed 10 hours prior to milking; 2 trials					
Average score	38.1	37.7	38.7	38.7	38.3
Cows received molasses-concentrate feed 2 hours prior to milking; 4 trials					
Average score	35.1	38.1	37.2	38.0	37.1

* The samples were scored according to the American Dairy Science Association score card, which allows 45 points for flavor.

for 15 hours. The samples then were pasteurized at 143° F. for 30 minutes; cooled to 60° F., and scored for flavor by 3 experienced judges.

The average flavor score of milk obtained when no feed was consumed by the cows 10 hours before milking, was only 1.2 points higher than when mixed concentrates containing 10 per cent of citrus molasses were fed 2 hours before milking. At least part of this difference in score can be attributed to the concentrate mixture itself. Also, the milk from cow No. 664 increased in saltiness during the course of the experiment. While some feed flavors were noted, they were neither intense nor objectionable. It is believed that if this product was fed at milking time, no noticeable effect on flavor of milk would result.

CITRUS MOLASSES IN GRASS SILAGE

Blackstrap molasses is used in ensiling grasses and legumes. In its stead, a trial was conducted using Napier grass (*Pennisetum purpureum* Schumach), ensiled without molasses, 2 levels of citrus molasses with Napier grass and one level with pigeon peas (*Cajanus indicus* Spreng.). The levels of citrus molasses used with the forage are shown in table 3.

The relative palatability of these four silages was observed with nine Jersey heifers, based upon the number of animals eating each silage, and the heifers showed a decided preference for the molasses-Napier over the

TABLE 3

Effect of ensiling Napier grass and pigeon peas with citrus molasses, upon its palatability to Jersey heifers

Forage	Proportion of citrus molasses added	Aroma of silage	pH	Preference of heifers
	%			
Napier grass	0	Fair to good	4.08	3rd
" "	2	Excellent	3.86	1st
" "	4	Excellent	3.95	2nd
Pigeon peas	4	Good	5.08	4th

plain Napier silage. Although the pigeon pea silage rated fourth in palatability, it ensiled well with the added citrus molasses, and had a desirable aroma.

SUMMARY AND CONCLUSIONS

Citrus molasses is replacing cane molasses in part of the mixed dairy feeds. Over 4700 tons were obtained in the second year of operation, it being recovered along with dried citrus pulp as by-products of the citrus canning industry. Reducing and non-reducing sugars constitute two-thirds of the dry matter. No fiber, little fat, 4 per cent of crude protein, and over 0.9 per cent of calcium citrate were present. Values of 1.4 per cent of digestible crude protein and 56.7 per cent of total digestible nutrients were estimated by applying the digestion coefficients for beet and cane molasses.

Dairy cows found citrus molasses highly palatable mixed in concentrates at 5 and 10 per cent levels, but much less so when first offered separately. A slight feed flavor was imparted to milk when fed 2 hours before milking time. The flavor was neither intense nor objectionable.

Additions of citrus molasses to a non-saccharin grass (Napier) at 2 and 4 per cent levels improved aroma and palatability of the silage. Pigeon peas ensiled satisfactorily with a 4 per cent addition of citrus molasses.

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THE EFFECT OF FEEDING COTTONSEED MEAL AS THE ONLY CONCENTRATE ON SEVERAL PROPERTIES OF MILK. I. FAT, TOTAL SOLIDS AND ASH CONTENT*

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Cottonseed meal has been one of the most commonly used protein supplements for dairy cows. In the southern states where this meal is the principal locally-produced concentrate feed, it is usually the cheapest source not only of protein but also of total digestible nutrients available to the dairyman. Therefore, it is often economical to feed cottonseed meal as the only concentrate to dairy cows.

Research work at various stations (5, 7, 9, 10, 13, 14, 16) indicate that cottonseed meal is a satisfactory concentrate for dairy cows when it is supplemented with adequate amounts of vitamin A and calcium.

It is recognized that many factors may cause variations in the composition of milk. The results of numerous experiments indicate that the fat, the most variable constituent of milk, cannot be altered permanently to any marked degree when the cow receives what is considered as an adequate ration, but many feeds of high oil content, including cottonseed meal, have been shown to cause at least a temporary increase in the fat percentage (1, 2). In contrast prickly pear and certain oils, such as cod liver oil, have been found to decrease the fat percentage (11, 21). Furthermore, it is extremely difficult to relate directly the variations in the solids-not-fat and the ash of the milk to the feed of the cow. Taylor and Husband (20) and other workers have shown that feed can alter the composition of milk indirectly through an effect on the milk production. The percentage of total solids, of fat and of ash usually is found to vary inversely and the percentage of lactose directly with the volume of milk yielded. Recently Riddet *et al.* (18) have confirmed observations that subnormal feeding results in a decrease of the percentage of solids-not-fat in milk along with a reduction in volume produced.

Since general economic and nutritional conditions in the South indicate the need of conserving and utilizing all the constituents of milk for human consumption, this study was concerned primarily with the effect of cottonseed meal on the milk solids collectively as well as individually.

EXPERIMENTAL

The effects of feeding cottonseed meal as the only concentrate to dairy cows were studied by comparing the properties of the milk produced by a

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group of cows receiving cottonseed meal (plus 2 per cent bone meal and 1 per cent salt) with the properties of milk produced by a similar group receiving a concentrate mixture of 400 pounds corn gluten meal, 200 pounds wheat bran, 200 pounds ground corn, 200 pounds ground oats (plus 2 per cent bone meal and 1 per cent salt). The roughage received was the same for the two groups, either corn and soybean silage or pasture.

The cows used in this experiment were carefully selected from the Holstein herd so that each cow on the cottonseed meal ration was paired with a comparable cow on the control ration. An attempt was made to maintain from eight to ten cows in each group; however, at times the number dropped to five cows per group.

A comparison of the milk from the two groups as to total solids, fat and ash content (4) over a period of sixteen months is presented in figure 1.

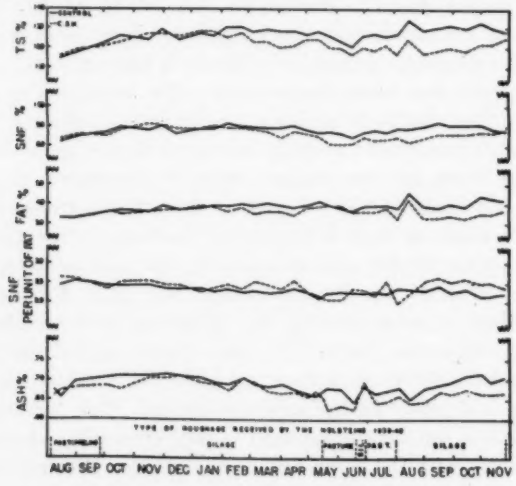

FIG. 1. The total solids, solids-not-fat, fat, ratio of fat to solids-not-fat and ash in the milk produced by a group of cows receiving cottonseed meal as the only concentrate compared with the same constituents in the milk produced by a similar group receiving a normal concentrate mixture.

During the first four months the groups were receiving their respective rations, no differences were evident in the fat and total solids content of the milks. After this time, the milk produced by the cows receiving the cottonseed meal began to have a consistently lower fat and total solids content than the milk from the control group. An exception to this difference in fat content occurred for a brief time when the cows were released on pasture in May.

The solids-not-fat content of the milk from the two groups follows the same trend as the total solids and fat. The ratio of the solids-not-fat to fat

indicates that there was a tendency for the fat to be lower in proportion to the solids-not-fat in the milk from the cottonseed meal group than in that from the control group. This tendency did not hold true during the period the roughage was being interchanged with silage and pasture.

The ash content of the milk from the two groups of cows showed no significant differences until the cows were turned on pasture. This change in roughage was accompanied by a drop in the ash of the milk from the cows receiving the cottonseed meal. The ash increased when the cows were returned to silage, but dropped again when returned to pasture and then remained low even though the cows were once more fed silage.

DISCUSSION

It may be significant that four months on the rations elapsed before any differences in total solids and fat became evident. The differences in the composition of the milk from the two groups showed no apparent correlation with the quantity of milk produced (unpublished data) except for the higher fat and lower production from the cottonseed meal group at the time the cows were first turned on pasture in May. At this stage, several individuals of the cottonseed meal group underwent a temporary physiological upset characterized by anorexia, decreased milk production and abortions. At the same time, the production of the control group increased and the general health of the animals remained good. Under these conditions variations in the composition of the milk were to be expected. The question as to whether the effects on the cows in the test were related to the cottonseed meal ration or to some other factor or factors coincidental with the progress of the experiment remains unanswered. There was no definite indication that the cows were suffering at any time from either a vitamin A or a calcium deficiency.

After the differences in composition of the milk from the two groups had become established, it was planned to reverse the groups, but so many cows had to be removed from the cottonseed meal ration that the group became too small to continue. Another paired series, using Jerseys, was placed on a similar regime. After a period of about four months, the same differences in fat and total solids observed in the milk of the Holstein groups became evident in the Jerseys; but since still more difficulty was experienced in maintaining the organization of these groups, the results cannot be accepted as definite confirmation of the data reported for the Holsteins.

Hills *et al.* (12) and Perkins (17) concluded from their investigations that the level of protein feeding does not affect the composition of milk. On the contrary, Stewart and Tocher (19) observed a decrease in percentage of solids-not-fat from feeding a high protein ration, and Keith *et al.* (15) reported a lower fat and specific gravity in the milk produced on a ration of cottonseed meal and prairie hay than in the milk produced on a standard

herd ration. Although there were other factors involved in the experiment reported in this article, the results indicate that the level of protein feeding might affect the composition of the milk.

The differences in ash content of the milk from the two groups tended to follow the same trends as the differences in solids-not-fat. Becker *et al.* (6) found that calcium and phosphorus of milk remained normal even though the cows were suffering from a severe deficiency of these elements. This is in accord with the general belief that feed does not directly affect the ash content of milk (8). On the other hand, it has been shown that certain elements of the ash can be increased by feed (3). Interesting results might have been obtained from a study of the elemental composition of the ash of the milk from the two groups.

SUMMARY

The percentage of fat, total solids and ash of the milk produced by a group of Holstein cows receiving cottonseed meal as the only concentrate was compared with that of a similar group receiving a mixture of corn gluten meal, wheat bran, ground corn and oats. The roughage was the same for the two groups. The data collected covered a feeding period of sixteen consecutive months.

Four months after placing the animals on their respective experimental rations the milk produced by the group receiving the cottonseed meal ration had a lower percentage of total solids, fat and solids-not-fat than that from the control group. Later the ash content likewise became lower.

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THE EFFECT OF FEEDING COTTONSEED MEAL AS THE ONLY CONCENTRATE ON SEVERAL PROPERTIES OF MILK. II. NITROGEN DISTRIBUTION*

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Investigations (2, 5, 9, 11) have shown that feeding a high level of protein increases the non-protein nitrogen content of the milk. Although this is generally accepted to be the only direct effect of feed on the nitrogen composition of milk, some investigators (3, 10) have observed a slight variation in other nitrogen fractions accompanying changes in the level of protein feeding.

In a preceding report (4) the total solids, the fat and the ash content of the milk produced by a group of cows receiving cottonseed meal as the only concentrate were compared with the content of the same constituents in the milk produced by a comparable group of cows receiving a normal concentrate mixture. Since any major change in the nitrogen fractions of milk may be expected to influence its manufacturing characteristics, an additional study of the properties of the milk from the foregoing groups included determinations of the nitrogen distribution of the milk.

EXPERIMENTAL

The total nitrogen, the casein nitrogen, the non-casein protein nitrogen and the non-protein nitrogen (7) in the milk produced by the two groups of cows are presented in figure 1.

Immediately after placing the cows on their respective concentrate rations, the non-protein nitrogen in the milk from the cottonseed meal group increased; whereas that from the control group decreased slightly. For the most part, this difference was uniform throughout the remainder of the experimental period. This parallelism was maintained even though there were variations from time to time in the level of the non-protein nitrogen. When the animals were released on pasture, this nitrogen fraction increased, and when silage feeding was resumed, it decreased.

The non-casein protein nitrogen fraction of the milk from the two groups showed no difference that could be attributed to the rations.

During the first four months, no differences were evident in the casein nitrogen content of the two milks. After this period, when a difference in fat and total solids was observed (4), the milk from the cottonseed meal group had a lower casein nitrogen content than the milk from the control

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group. This difference was accentuated when the cows were turned on the pasture, particularly during the first grazing period. The precipitous drop in this constituent noted during this period was associated with a change in the physiological condition of several cows in the cottonseed meal group (4).

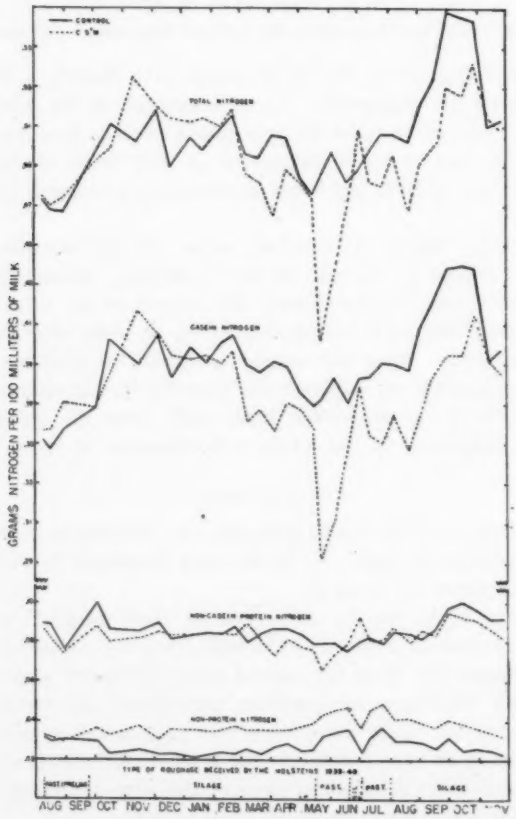

FIG. 1. The amount of total nitrogen, casein nitrogen, non-casein protein nitrogen and non-protein nitrogen in milk produced by a group of cows receiving cottonseed meal as the only concentrate compared with the same nitrogen fractions in the milk produced by a comparable group of cows receiving a normal concentrate mixture.

Apparently the differences in the level of the total nitrogen in the milks from the two groups were due primarily to the relative levels of the non-protein nitrogen and the casein nitrogen fractions. The increase in non-protein nitrogen in the milk from the cottonseed meal group tended to increase the total nitrogen to a higher level than that in the milk from the

control group until changes in the casein nitrogen began to counterbalance the effects of the non-protein nitrogen. The reduction of the casein nitrogen in the milk from the cottonseed meal group apparently was sufficient to offset the higher non-protein nitrogen. Hence, the total nitrogen was first

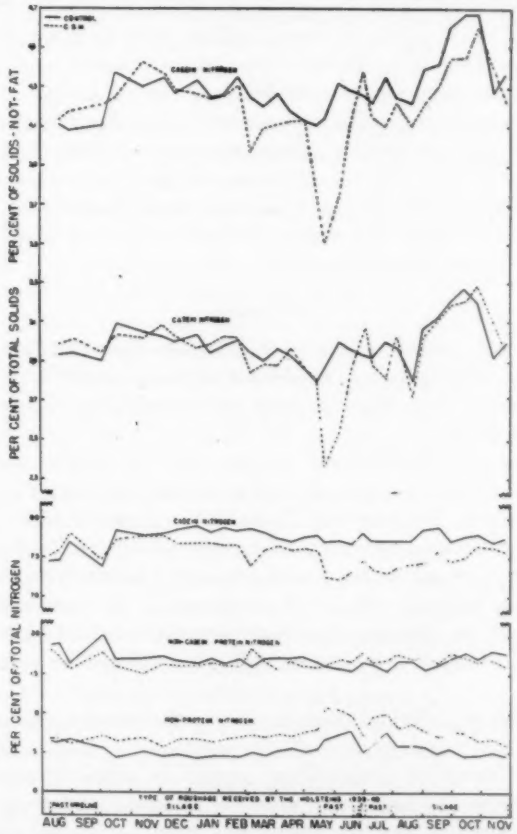
PER CENT OF SOLIDS-NOT-FAT
PER CENT OF TOTAL SOLIDS
PER CENT OF TOTAL NITROGEN
AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV

FIG. 2. The per cent of total nitrogen as casein, non-casein protein and non-protein nitrogen, and the per cent of total solids and of solids-not-fat as casein nitrogen in the milk produced by a group of cows receiving cottonseed meal as the only concentrate compared with the same nitrogen distribution in the milk produced by a comparable group of cows receiving a normal concentrate mixture.

higher and then lower in the milk from the cottonseed meal group than in the milk from the control group.

The two sets of curves for casein nitrogen, figure 2, show that this fraction calculated as per cent of the solids-not-fat follows the same trend

and shows the same general group relationships as it does when expressed in terms of grams per 100 milliliters of milk, figure 1. However, when expressed on a basis of per cent of the total solids in the milk, the aforementioned apparent differences between the two milks was not in evidence, except for the period when the cows were physically upset. This indicates that the fat (4) in the milk decreased sufficiently to keep the ratio of casein nitrogen to total solids in the milk from the cottonseed meal group about equal to the same ratio for the milk from the control group.

The remaining three sets of curves presented in figure 2 show the distribution of the total nitrogen as casein, non-casein protein and non-protein nitrogen. The lower percentage of casein nitrogen from the cottonseed meal group, as compared with that of the control group, is due partly to a diluting effect of the increased non-protein nitrogen and partly to a definite lower casein in relation to the solids-not-fat.

DISCUSSION

The high non-protein nitrogen observed in the milk from the group receiving cottonseed meal is in agreement with reports (2, 5, 9, 11) that the level of protein feeding affects directly the amount of non-protein nitrogen present in the milk.

Most of the published reports indicate that the protein nitrogen in the milk is not affected by the level of protein feeding, although a slight increase has been observed. Stewart and Tocher (10) reported that albumin and globulin were increased but that casein was not affected. Hills *et al.* (3) found a slight increase in the casein-albumin fraction with an increasing level of protein feeding. The results reported in this article indicate that the albumin and the globulin apparently were not affected by feed; whereas casein instead of being increased actually was lowered by cottonseed meal feeding.

Riddet *et al.* (6) observed that casein was decreased by subnormal feeding, but the cows in the experiment reported in the present article hardly could be considered on a subnormal ration in terms of total digestible nutrients. Davies (1) found that milk low in solids-not-fat was also low in casein and especially low in lactose but high in non-protein nitrogen, albumin, and globulin nitrogen. If the amount of lactose is calculated from the results reported here (4), the doubtful condition of both a low lactose content and a low ash is shown in the milk from the cows receiving cottonseed meal as compared with milk from the control group.

Using Rowland's (8) value of 77.0 as the lower limit for casein nitrogen, expressed as per cent of total nitrogen for normal milk, the cows on the cottonseed meal ration could be considered as secreting abnormal milk after being on this ration about three months. Rowland has indicated that milk of this type is characteristic of that from cows suffering from sub-

clinical mastitis. Although no special study was made regarding this point, there were no apparent indications that the cottonseed meal group of cows was any more susceptible to udder troubles than the control group.

Results from the groups of Jerseys mentioned in a previous article (4) tended to confirm the effects of cottonseed meal feeding on the non-protein and casein nitrogen of milk as reported in this article.

SUMMARY

The nitrogen distribution of the milk produced by a group of cows receiving cottonseed meal as the only concentrate was compared with that of milk from a comparable group receiving a concentrate mixture of corn gluten meal, wheat bran, and ground corn and oats. The roughage was the same for the two groups.

The milk from the cottonseed meal group had a higher non-protein nitrogen content than that from the control group.

The two systems of feeding resulted in no apparent differences in the non-casein protein nitrogen content of the milk.

About four months after placing the cows on their respective experimental rations, the group receiving cottonseed meal as the only concentrate began to produce milk of a lower casein nitrogen content than did the control group.

The comparatively lower casein nitrogen was accompanied by a lower fat and total solids content in such a ratio that the casein nitrogen expressed as per cent of total solids was the same for both groups.

Differences in the total nitrogen content of the two milks were dependent on the relative levels of non-protein and casein nitrogen; hence the total nitrogen was first higher and then lower in the milk from the cottonseed meal group than in the control group.

The quantity of milk produced by the two groups of cows was essentially the same; therefore the differences in properties of the milk reported in this series of articles cannot be related to the milk yields.

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THE EFFECT OF FEEDING COTTONSEED MEAL AS THE ONLY CONCENTRATE ON SEVERAL PROPERTIES OF MILK. III. pH, RENNET COAGULATION, HEAT COAGULATION AND CURD TENSION*

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Any factor altering the composition of milk may be expected to affect the physical-chemical properties of the milk, while the physical-chemical properties of milk can be altered without any detectable change in milk composition. For instance, an affect on the rennet coagulation of milk may or may not be accompanied by a detectable change in milk composition (5, 6, 11, 13).

The belief that feed does not directly affect the composition of the milk has led to the general opinion that such properties as pH, rennet coagulation, heat coagulation, and curd tension are likewise not affected by the ration. Investigations have shown that acids in the ration do not alter the acidity of the milk (1, 10). Neither factors affecting the curd tension of milk (2) nor other coagulation characteristics of milk have been definitely related to the feed consumed by the cow.

In preceding reports the total solids, the fat and the ash content (8) and the nitrogen distribution (9) in the milk produced by a group of cows receiving cottonseed meal as the only concentrate were compared with the same properties in milk produced by a comparable group of cows receiving a normal concentrate mixture. The cottonseed meal group of cows produced milk of a lower solids content than the control group; hence, other properties of the milk might be expected to have been affected. Thus additional data from milk samples previously described (8, 9) are presented in this report.

EXPERIMENTAL

The hydrogen ion concentration of the milk samples was determined with a glass electrode pH meter. The rennet coagulation time was obtained by the procedure as outlined by Sommer and Matsen (12). The heat coagulation was studied by recording the time required for the milk to coagulate when sealed in small glass tubes and immersed and agitated in an oil bath at 136° C. (7). The effect of small changes in the salt balance of the milk on the heat coagulation was determined by recording the time required for coagulation of various milk samples to which calcium acetate and sodium diphosphate, respectively, had been added at the rate of 0.4 ml. of M/4 salt per 50 ml. of milk. The procedure recommended by the Committee on

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Methods of Determining the Curd Tension of Milk (3) was used for studying the curd tension of the milk samples. In addition to the determination of the maximum grams required for cutting the surface the weight for cutting the body of the curd also was recorded.

A comparison of the pH, the rennet coagulation, the heat coagulation and the curd tension of the respective milks produced by the two groups of cows is presented in figure 1.

The milk from the cottonseed meal group had a slightly but consistently higher pH than the milk from the control group during the first few months

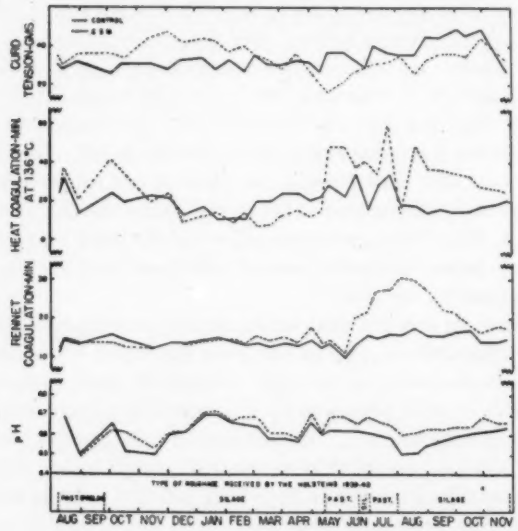
CONTROL
C S M
CURD TENSION-GMS
HEAT COAGULATION-MIN. AT 136 °C
RENNET COAGULATION-MIN.
pH
AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV

FIG. 1. The pH, rennet coagulation, heat coagulation and curd tension of the milk produced by a group of cows receiving cottonseed meal as the only concentrate as compared with the same properties of the milk produced by a comparable group receiving a normal concentrate mixture.

of the feeding trial. The change from silage feeding to pasture grazing was accompanied by a still greater spread in the pH values of the two milks, the increased difference persisting throughout the remainder of the trial.

After the first four months, when the milk from the cottonseed meal group began to have a lower solids content (8), the rennet coagulation time for this milk began to be slightly greater than for the control milk. A few weeks after turning the cows on pasture the rennet coagulation time for the milk from the cottonseed meal group increased markedly over a period of about three months and then gradually returned to near the normal level after silage feeding was resumed.

The heat coagulation of the milks showed no uniform and definite differences; however, when the cows were changed back and forth from pasture to silage, the heat coagulation of the milk from both groups fluctuated considerably, the milk from the group on the cottonseed meal ration tending to be more stable to heat than that from the control group.

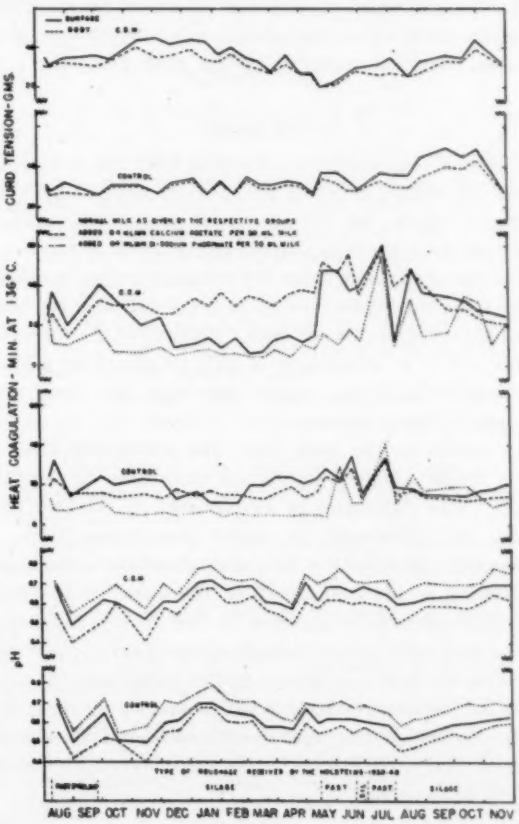

FIG. 2. The effects of added salts on the pH and the heat coagulation, and the differences between surface and body curd tension of the milks produced by the groups of cows on a cottonseed meal and control rations.

During the first few months the curd tension of the milk from the cottonseed meal group was higher, but for the remainder of the trial it was lower than that from the control group. There seemed to be a direct relationship between the lower solids content of the milk (8) and the lower curd tension. As shown in figure 2 there is a marked parallelism between the surface curd tension and the body curd tension in the respective samples of milk.

The additions of calcium acetate and of di-sodium phosphate to the milks had the same effect on the pH of the two milks, but different effects on the heat coagulation as is indicated by the curves presented in figure 2. The addition of phosphate always increased and the addition of calcium always decreased the pH of the milk samples. The heat coagulation time for the milk from the control group usually was decreased by the addition of either salt; whereas the addition of the calcium salt usually increased while phosphate decreased the heat stability of the milk from the cottonseed meal group.

DISCUSSION

The general differences between the milk from the cottonseed meal group and that from the control group in pH, rennet coagulation, heat coagulation and curd tension follow, for the most part, trends that could be predicted from the differences in the composition of the milks (8).

The higher pH of the milk from the cottonseed meal group in comparison with the milk from the control group is in accord with the lower solids-not-fat content of the cottonseed meal milk. Keith *et al.* (4) observed these same general differences in a comparison of milk produced by a group of Jerseys receiving cottonseed meal and prairie hay with that from a similar group receiving a standard herd ration.

The lower solids in the milk from the cottonseed meal group would account for a longer rennet coagulation time than for the milk from the control group. The difference in ash content of the two milks is also in harmony with the differences in rennet coagulation time. The marked increase in coagulation time for the group from the cottonseed meal group occurred following a physical upset of the cows on the cottonseed meal ration (8). This prolonged increase in the rennet coagulation time was probably associated with the physiological condition of the cows.

The effects on the heat coagulation of the milks from the two groups were variable, but the results revealed a difference in the heat stability. The differences in coagulation time and in composition of the comparative whole milks suggested that a difference in the heat stability of their evaporated products might be expected.

SUMMARY

The pH, rennet coagulation, heat coagulation and curd tension of the milk produced by a group of cows receiving cottonseed meal as the only concentrate were compared with the same properties of milk produced by a comparable group of cows receiving a normal concentrate mixture.

These properties of the milks follow the same general trend as the differences in composition of the two milks.

The milk from the cottonseed meal group had a higher pH than that from the control group. The slight difference observed during the first few months increased as the difference in total solids increased.

The milk from the cottonseed meal group required longer to coagulate by rennet than that from the control group after about the first five months of the feeding trial.

Variable differences were recorded for the heat coagulation of the milks. The data suggest a practical problem relative to the heat stability of the evaporated products produced from milk of cows receiving a high level of cottonseed meal in the ration.

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THE EFFECT OF FEEDING COTTONSEED MEAL AS THE ONLY CONCENTRATE ON SEVERAL PROPERTIES OF MILK. IV. FAT CONSTANTS*

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Numerous reports in the literature show that many feeds affect the composition of milk fat. A great number of these records are concerned with cottonseed and cottonseed products as dairy feeds. Although most of the investigations recorded are in agreement relative to the specific effects of cottonseed meal upon the fat properties, the few discrepancies noted may be explained partially on the basis of the role played by such factors as length of feeding period, type of basal ration, method of comparison, etc., on the nature and degree of alteration of milk fat.

Most of the studies of the effect of feeding cottonseed meal on milk fat composition have been for short periods, and many of the investigators have given little consideration to the type of basal ration and to the maintenance of adequate control groups of cows.

Since the composition of the fat is known to be influenced easily by feeds and since the effects of cottonseed meal feeding over a short duration of time have been fairly well established, it was deemed desirable to determine the comparative effects of protracted cottonseed meal feeding on some of the constants of the fat from the milk samples obtained under conditions previously reported (2, 3, 4). Furthermore, since the composition of the fat has been shown to be related to its susceptibility to oxidation (5), observations were made on the comparative effects of the feeds on the oxidation of filtered milk fat.

EXPERIMENTAL

The fat samples were obtained from milk produced by two comparative groups of cows, one of which received cottonseed meal as the only concentrate, while the other received a normal grain mixture. The respective milk samples were pasteurized and churned. The resulting butter was then melted and filtered for subsequent study.

The saponification number, iodine number, Reichert-Meissl number, butyro-refractometer degrees, stability value (5) and acid degree of the fat samples were determined. The data obtained are presented in figure 1 and in table 1.

The milk fat from the cottonseed meal group had a lower saponification number than that from the control group, a relationship which would be

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predicted from a review of the literature. However, for a short period during the sixth and seventh months of the feeding trial this difference was practically nil. It is not known whether the latter deviation from the expected results was due to the ration or to some other cause.

For most of the feeding period the milk fat from the cottonseed meal group had a higher iodine number than that of the control group. During the seventh month, the iodine number, as did the saponification number, failed to show the expected difference in the two milk fats. While the cows were being transferred back and forth from silage to pasture, the differences

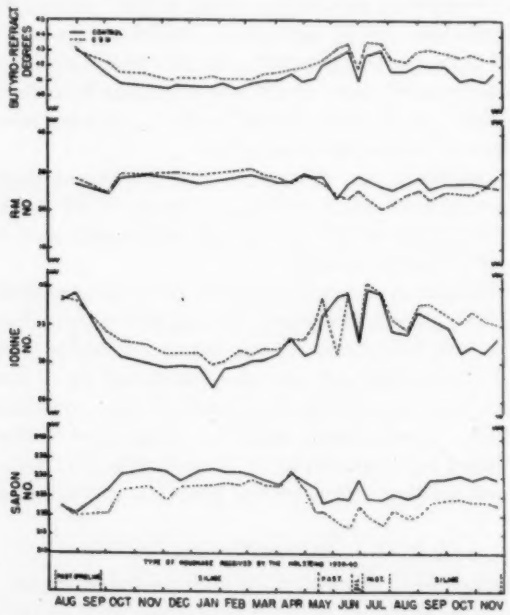

FIG. 1. The saponification number, iodine number, Reichert-Meissl number and butyro-refractometer degrees of the milk fat produced by a group of cows receiving cottonseed meal as the only concentrate as compared with the same fat constants of the milk fat produced by a comparable group of cows receiving a normal concentrate mixture.

in the iodine number were variable, which is in harmony with the results presented in the literature. The iodine number is easily influenced not only by the concentrate but also by the type of roughage. The effects of a change in roughage on the iodine number depend upon the concentrate fed; hence, the variable results obtained during these sudden changes in roughage might have been expected.

The Reichert-Meissl numbers obtained show the greatest deviation from the expected. During the first nine months of the feeding trial, these values

for the milk fat produced by the two groups were practically the same. For the remainder of the trial the milk fat from the cottonseed meal group had the lower Reichert-Meissl number as expected. Although the effects of oil feeds are known to be modified by silage and by pasture, neither this nor any other known factor explains adequately the long time required for the cottonseeed meal to affect the volatile acids of the milk fat.

The refractive index was the only fat constants that revealed a consistent difference between the milk fats from the two groups of cows. The milk fat from the cottonseed meal group always had a higher refractometer reading than that of the control group. Most of the reports in the literature show a similar increase of the refractive index resulting from the feeding of cottonseed and its products.

TABLE 1

The stability value and acid degree of milk fat produced by cows receiving cottonseed meal as the only concentrate compared with milk fat from cows receiving a normal grain mixture

Date sampled	Stability value		Acid degree	
	C.S.M.	Control	C.S.M.	Control
7–24–40	27.5	32.0	0.42	0.56
8– 6–40	34.5	33.5	0.65	1.35
8–20–40	32.0	33.0	0.57	0.60
9– 3–40	32.0	36.0	0.54	0.78
9–17–40	28.5	39.0	0.62	0.72
10– 1–40	26.0	32.0	0.70	0.57
10–15–40	21.0	25.0	0.60	0.58
10–29–40	28.0	35.0	0.58	0.58
11–12–40	18.0	30.0	0.74	0.54
11–26–40	34.0	37.0	0.56	0.43

A number of factors are known to affect the values obtained in the determination of the susceptibility of fat to oxidation. After eliminating the possibility of the usually recognized sources of error, it was found that an additional factor, the presence of free fatty acids, had a greater influence on fat oxidation than anticipated (1). Before the effect of feed could be measured, it was necessary to eliminate the possibility of even slight lipolytic action on the milk fat.

A few comparisons of the stability value (5) and of the acid degree of the milk fat produced by the two groups of cows are presented in table 1. The milk fat from the cottonseed meal group was found to be less stable toward oxidation than that of the control group. This agrees with investigations showing that the stability of filtered fat varies with the degree of unsaturation. No consistent difference was observed in acid degree between the two milk fats. Unpublished preliminary work on the determination of free fatty acids in milk shows that the churning method probably is not a reliable procedure for obtaining fat for use in measuring the free fatty

acids in milk. Thus the acid degrees presented herein may or may not represent the true relative values.

SUMMARY

In general the feeding of cottonseed meal as the only concentrate as compared with feeding a normal grain mixture decreased the saponification number and increased the iodine number and the refractive index. The expected decrease in Reichert-Meissl number did not become evident until after nine months of the feeding period had passed.

In a similar comparison, the milk fat from the cottonseed meal group was less stable toward oxidation than that from the control group. No difference in acid degree of the two milk fats was detected.

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THE CORRELATION BETWEEN SOME CHARACTERISTICS OF DAIRY BULL SEMEN AND CONCEPTION RATE*

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The accurate evaluation of freshly drawn and stored bull semen before use is of prime importance in artificial insemination. The detection before use and discarding of semen samples likely to result in poor conception rates is most important in securing maximum efficiency. The physical and chemical characteristics which have been commonly proposed for the evaluation of semen are pH, concentration, motility, viability in storage, percentage of abnormal sperm, glycolysis rate, respiration rate, reduction tests, resistance to various shock treatments, percentage of live sperm, etc. This paper reports a study of the correlation between the first five of the characteristics listed above and the conception rate of the semen as used in the University of Missouri Dairy Herd.

MATERIALS AND METHODS

The semen studied was largely from University of Missouri bulls of the Holstein-Friesian, Guernsey and Jersey breeds. Cows inseminated were nearly all in the University of Missouri herd, but a few cows and bulls in outside herds have been included in the data. Semen from twenty-three bulls was studied. The bulls studied represented all phases of fertility from practically sterile to highly fertile. The bulls ranged from fifteen months to thirteen years of age.

All inseminations were made by cervical deposition by the use of a speculum as described by Herman and Ragsdale (4). Pregnancy determinations have been supported in most cases by calvings, and in others by manual examinations for presence of fetus or failure of cow to return to heat within 90 days after insemination. The data cover the years 1940 to 1942 and the early part of 1943. Insemination of cows which never conceived or were known to have malfunction of the ovaries or other reproductive trouble were omitted from the study.

The methods used in examination of the semen have been described previously (5). These were simple tests which could be done satisfactorily with little technical skill. The rating of motility from 0 to 5 lacks somewhat in precision, and further study of accurately counting the motile sperm shows that a small number of very active spermatozoa may make the semen appear as good in motility as a larger number of slowly moving sperm.

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Since the vigor of motion as well as the amount is an important test of fertility (2, 7), the rating method may be of great value in spite of its error in estimating the actual number of sperm which are motile. Actual counts have shown that the previously estimated percentage of motile sperm for the different ratings was too high. Semen of 5 motility has about 80 per cent or more progressively motile sperm; 4 motility, 70 to 85 per cent; 3 motility, 45 to 75 per cent; 2 motility, 20 to 50 per cent; and 1 motility is usually below 25 per cent of progressively motile sperm.

Since two or more cows were seldom inseminated with any one sample of semen, the data were grouped to facilitate correlation analysis. All inseminations were tabulated in class interval groups of the semen characteristic as to whether or not they resulted in conception, and the percentage of samples resulting in conception was calculated for each group. The coefficients of linear correlation, r, were then determined for the various semen characteristics and conception rate.

RESULTS

The results secured are presented graphically in figure 1 for all of the characteristics studied except pH. The importance of pH readings was in doubt early in the period covered, hence the pH of all samples was not determined as a routine procedure. The pH of semen used for 205 inseminations was recorded, however. These were grouped in classes of 0.2 pH unit interval from pH 5.8 to 7.4. The correlation coefficient, r, for pH and conception rate was -0.18 which indicated that there certainly was not a correlation between the two.

The percentage of abnormally shaped sperm in semen used in 525 inseminations was tabulated in groups at intervals of 3 per cent from 0 to 30 per cent. As shown by the chart (fig. 1) and the correlation coefficient of -0.12 there was no correlation between conception rate and percentage of abnormal spermatozoa in the range studied. Bulls producing extremely large numbers of abnormally shaped sperm, however, may be low in fertility (5).

The concentration of sperm in semen used in 559 inseminations was tabulated in groups at intervals of 200 per mm.^{3} from 200 to 2000. As shown in figure 1 there was a slight tendency for the more concentrated semen to produce a larger percentage of conceptions. The correlation coefficient, 0.63, was just short of significance, since an r of 0.666 is required (3) for the expression of a significant correlation within a probability of 0.05. The concentration of sperm was, therefore, not an important factor in the determination of conception rate.

Semen used in 475 inseminations was tabulated as to the length of time a motility rating as good as 2 was maintained in the undiluted semen during storage at 40° F. Daily motility ratings of the stored semen were made; so the samples were grouped at intervals of 24 hours up to 192 hours. Forty-one per cent of inseminations from semen that kept a motility rating of 2 for

less than one day after use produced conceptions. As viability of the semen increased the conception rate increased until 68 per cent of inseminations with the most viable semen group resulted in conception. The correlation coefficient, 0.84, showed that there was a highly significant linear correlation between viability of the sperm in storage and their ability to produce pregnancy.

The motility ratings of semen used in 565 inseminations were tabulated according to the fertility of the semen. As shown in figure 1, plotting the motility ratings against conception rate did not indicate a linear correlation.

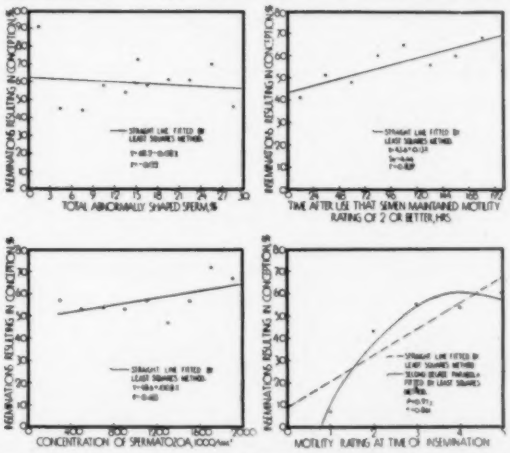
INSEMINATIONS RESULTING IN CONCEPTION %
TOTAL ABNORMALLY SHAPED SPERM %
TIME AFTER USE THAT SEMEN MAINTAINED MOTILITY RATING OF 2 OR BETTER, HRS.
CONCENTRATION OF SPERMATOZOA, 1000's/mm³
MOTILITY RATING AT TIME OF INSEMINATION

FIG. 1. The correlation between conception rate and semen quality as expressed by motility estimation, viability, concentration of sperm, and abnormal morphology of sperm.

Conception rate from semen of 1 motility was very poor. Semen that was 2 motility was not very satisfactory since only 43 per cent of such inseminations resulted in conception. Semen of 3 motility was correspondingly better than semen of 2 motility as 2 had been better than 1. Conception rate of semen which was rated 4 and 5, however, was not significantly different from that of semen rated only 3, although semen rated 5 motility did give the best conception rate. The relation between motility rating and conception rate was therefore curvilinear. Conception rate increased as motility increased up to the 3 rating, and thereafter increased motility did not result in important increases in conception rate. The index of correlation, ρ, should therefore be used to measure the degree of correlation between the two. The index of correlation, 0.97, revealed that there was a significant curvilinear correlation between motility rating and conception rate.

DISCUSSION

This evaluation of five commonly used methods of determining semen quality has revealed some useful information for the practitioner. Accord-

ing to the results of this study there is little practical value in making routine pH determinations, abnormality counts, or determining the concentration of sperm. The information furnished by these determinations was not correlated significantly with rate of conception. Therefore, the rejection of a sample of semen because it is slightly abnormal in any of the three characteristics does not seem justified. The only reason for rejecting samples which are very high in pH or abnormalities or very low in concentration should be the extent to which such items are correlated with longevity and motility of the sperm. This problem has not been treated in this study. If samples are of acceptable motility and viability, it does not seem reasonable to reject them on the basis of pH and concentration, especially in view of the fact that the semen may be diluted many times with a buffered protective mixture. Semen that is very high in abnormal sperm usually does not have good motility or viability; but if it does have good motility and viability it will probably give good breeding efficiency.

The fine correlations shown between viability and conception rate are of more theoretical interest than practical interest because such information is not obtained until after use of the semen. This correlation can be used as a guide, however, in the development of other methods of semen evaluation. The high correlation of any test with viability should indicate its correlation with semen fertility. Beck and Salisbury (1) have used short-time high-temperature survival tests in this manner. Knowledge of the probable survival time of highly motile semen is important for selection of semen which must be stored as well as for the maintenance of good conception rates.

The curvilinear relationship between conception rate and motility rating of the semen at the time of insemination will be of special interest in the use of stored semen. Semen which is below a rating of 3 cannot be used with much confidence. Even though many pregnancies have resulted from semen of lower motility the chances of conception are so reduced that such practice may be worthwhile only in the case of very valuable sires. The data also indicate that practically as good results may be expected from semen of 3 and 4 motility as from the highest rating. These observations are in agreement with those of Lasley (6) who found no correlation between motility rating above 3 and the fertility of the semen. He also observed that there was not a significant difference in the fertility of semen containing from 55 to 95 per cent live sperm, but semen which contained only 20 per cent of live sperm was infertile. It therefore seems safe to conclude that semen should be 3 motility or better if good breeding efficiency is to be maintained. In terms of progressively motile spermatozoa, there should be about 45 per cent or more. This study has again demonstrated the value of the motility rating for detecting semen likely to result in poor breeding efficiency. Further study of the value of accurately determining the percentage of progressively motile sperm with reference to its correlation with viability is in progress.

SUMMARY

A study has been made of the correlation between semen characteristics and conception rate in the University of Missouri dairy herd. The correlation between conception rate and pH, abnormal sperm, and concentration of sperm was found to be non-significant. A highly significant linear correlation was found between conception rate and viability of the sperm. A significant curvilinear relationship between motility and conception rate was found. The difference in conception rate between semen rated 3 motility, which is usually 45 per cent or more progressively motile sperm, and higher grades of motility was very slight.

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SEASONAL VARIATION IN SEMEN QUALITY OF SOME MISSOURI DAIRY BULLS*

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The seasonal nature of sexual activity of many mammals is well recognized, but whether or not the bull has a definite seasonal sexual cycle has not been clearly demonstrated. Morgan and Davis (8) found that the conception rate of Nebraska dairy cattle was lowest in August and September, but months with high conception rate were not seasonal since January and July were both high and December was highest in conception rate. Erb, Wilbur and Hilton (5) reported a seasonal variation in breeding efficiency with spring (May at maximum) giving the best conception rate and late summer (August at minimum) giving the lowest conception rate. The separate effect of the bull and the cow upon fertility are confounded in ordinary analysis of breeding records, however.

Few studies have been made of seasonal variations in semen quality. Weatherby, Reece and Bartlett (11) reported monthly averages of semen volume, concentration, and longevity for six bulls in a New Jersey cooperative. Longevity, which is correlated with fertility (10), was generally higher in June and July than in other months, but the differences among the months were very slight. Anderson (1) presented monthly average semen volume and motility observations made on bulls in Kenya which indicated a rather distinct seasonal tendency. Volume and motility were both low from May to August. Erb, Andrews and Hilton (4) made a systematic study of the effect of season upon semen characteristics. Except for a noticeable increase in concentration in the spring, seasons other than summer had little effect upon semen quality. During July, August, and September the motility and semen volume were lowered, the sperm survived for a shorter period, and the percentage of abnormal forms was increased. Statistical analysis showed that semen obtained during the summer months was significantly of lower quality than that of other seasons. Lasley (7) found that beef bulls in Arizona gave higher quality semen as the season progressed from May to September. Volume of semen, percentage of live sperm, and percentage of resistant sperm increased during this period but concentration and percentage of abnormal sperm did not change.

The literature in general is not in complete agreement concerning the effects of season upon semen quality of bulls. The explanation of this fact may be that the effect of season is not as great in some localities as in others.

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In many cases the bulls studied were few in number and their individual responses to season (4) may not have been typical of the population. Since January, 1940, semen of a number of bulls in the University of Missouri herd has been examined regularly. Data for ten of these bulls extended over all four seasons, some of them for two or more years, and from three others, data from two or more seasons were available. This report presents an analysis of the monthly variation in quality of semen produced by these thirteen dairy bulls.

MATERIALS AND METHODS

The bulls were all purebred animals used as herd sires in the University of Missouri herd. Nine were Holstein-Friesians, three were Jerseys, and one was a Guernsey. They varied in age from one and one-half to thirteen years, but the majority of them were aged bulls, five year old or older. The average age was six years. Although these bulls were not all of high fertility, none was of consistently very low fertility.

During 1940, semen was collected from each bull at least once each week. Thereafter, however, collections were made only as they were needed for breeding or for various investigational purposes. All bulls were not represented, therefore, in every month of every year included in the study.

Each sample of semen was examined for initial motility, concentration, volume, number of abnormal sperm, and viability according to methods described previously (6). The pH of many of the semen samples was also determined (6).

The observations made on the semen from each bull were averaged by months, and the monthly averages for the separate bulls were then averaged to secure the grand average for that month. If data were available for a certain bull for two or more years for any month, each year's data were handled as a separate monthly average. Statistical significance of the differences among months and among bulls was determined by the analysis of variance according to Snedecor (9).

The bulls were fed a good quality legume hay and a grain mixture the year around. No pasture or green feed was given and no silage was fed. There was no seasonal difference in the rations.

RESULTS

Observations on 1103 ejaculates were included in this study. These were separated into 254 bull-month averages, resulting in an average of 4.34 ejaculates per month per bull. The largest number of ejaculates taken from one bull in any month was 12. Many bulls were collected from only once in certain months.

The monthly averages are presented in table 1. The number of bull-month averages from which the monthly average was computed and the

number of bulls represented are listed below the average of each month. The monthly averages are also presented graphically in figure 1.

The seasonal averages are presented in table 1. Winter was taken as January, February, and March. Spring months were April, May, and June. July, August and September were taken as summer; and October, November and December were designated fall months.

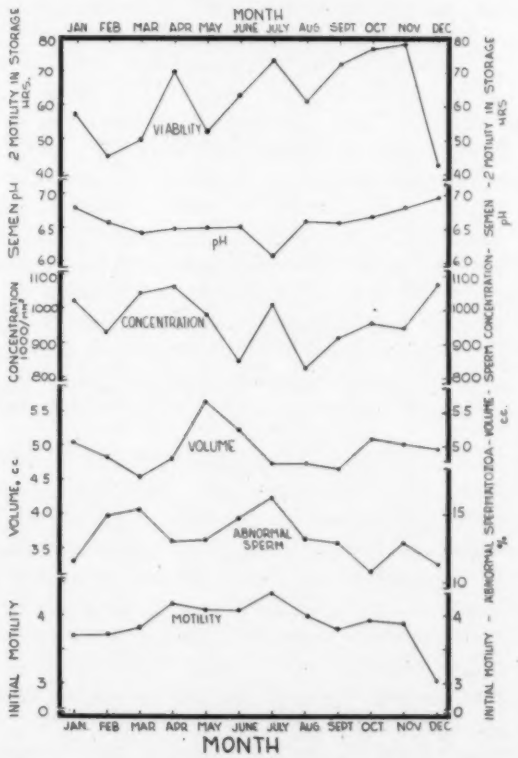

FIG. 1. Monthly averages of examinations for quality of semen from 13 Missouri bulls during 1940, 1941, and 1942.

The data in table 1 and the curves in figure 1 do not indicate very definite seasonal variations of some semen characteristics, but there is a suggestion that others may vary with the seasons. Volume appears to be greater in spring months, initial motility and viability are low in winter months, and pH is lower in summer than in winter. An examination of the original data revealed marked variation among bulls for certain characters in addition to variations among months by the same bull. Furthermore, all bulls did not

exhibit the same sort of seasonal variation. The nature of the data did not permit an accurate assignment of all of the sources of variation by the

TABLE 1

Monthly and seasonal summary of semen qualities

		Volume	Concentration	pH	Initial motility	Maintenance of 2 motility	Abnormal spermatozoa
		cc.	*1000/mm.³*			*hrs.*	%
January	Mean	5.04	1023.0	6.79	3.71	57.4	11.43
	No.	27	27	17	27	26	26
	Bulls	13	13	11	13	13	12
February	Mean	4.83	931.5	6.57	3.71	44.7	14.82
	No.	24	24	13	24	21	20
	Bulls	11	11	8	11	11	11
March	Mean	4.53	1046.1	6.42	3.81	49.3	15.29
	No.	24	24	10	24	23	20
	Bulls	12	12	8	12	12	12
April	Mean	4.80	1066.7	6.49	4.18	69.8	12.96
	No.	21	21	14	21	21	21
	Bulls	12	12	10	12	12	12
May	Mean	5.65	984.6	6.50	4.09	52.1	13.08
	No.	21	21	12	21	19	21
	Bulls	11	11	8	11	11	11
June	Mean	5.21	851.3	6.52	4.07	62.9	14.65
	No.	20	20	15	20	18	20
	Bulls	12	12	10	12	12	12
July	Mean	4.73	1015.9	6.09	4.33	73.8	16.21
	No.	18	19	7	19	19	18
	Bulls	11	11	7	11	11	11
August	Mean	4.75	831.3	6.60	4.02	61.5	13.25
	No.	17	15	7	17	14	15
	Bulls	10	10	7	10	10	10
September	Mean	4.67	917.9	6.58	3.81	72.1	12.93
	No.	21	21	7	21	21	21
	Bulls	11	11	7	11	11	11
October	Mean	5.12	961.0	6.68	3.94	77.2	10.75
	No.	21	21	11	21	21	21
	Bulls	11	11	9	11	11	11
November	Mean	5.04	944.7	6.81	3.90	78.8	12.96
	No.	18	19	13	19	18	18
	Bulls	11	11	9	11	10	11
December	Mean	4.98	1075.1	6.96	3.07	42.7	11.47
	No.	19	20	7	20	19	20
	Bulls	9	10	6	10	9	10
Year	Mean	4.95	975.7	6.60	3.88	61.6	13.23
	No.	251	252	133	254	240	241
	Bulls	13	13	13	13	13	13
Winter	Mean	4.80	1000.2	6.59	3.74	50.5	13.85
Spring	Mean	5.22	967.5	6.50	4.11	61.6	13.56
Summer	Mean	4.72	921.7	6.42	4.05	69.1	14.13
Fall	Mean	5.05	993.6	6.82	3.64	66.2	11.73

analysis of variance method (9). Variation among months and variation among bulls, however, were calculated and their significance was determined.

Volume. The differences in volume of ejaculates among bulls were highly significant. This finding was to be expected because bulls differ widely in this respect. The inter-monthly volume variations were not significant, however; hence a significant seasonal variation of semen volume was not found. Differences as great as were observed could have occurred at least 1 in 20 times as a result of chance. Thus, although the data are suggestive of a greater volume of ejaculate produced in spring than summer, the average difference of 0.5 cc. could easily have occurred as a result of chance.

Concentration. The differences in sperm concentration among bulls were highly significant. The differences among months, however, were not significant since they could be expected as a result of chance slightly more than 1 in 20 times. The same was true of the inter-seasonal differences. The concentration of sperm was, therefore, not significantly lower in summer than in winter.

pH. The pH differences among months were significant statistically. At $p = 0.05$ July's average was significantly lower than all other months, and December's average was significantly higher than all months except January, October, and November. The difference between the summer average and the fall average was highly significant ($p = < 0.01$). The pH of fall and winter semen seemed definitely higher than the pH of summer semen, but most of the difference was due to the very low values secured in July.

Initial motility. The differences in initial motility among the different bulls were highly significant. The differences among months were also highly significant. Using $p = 0.01$ as the level of significance the initial motility of July semen was significantly higher than that of December, January and February; and December was significantly below all other months. Using the lower level, $p = 0.05$, as a level of significance, April initial motility was significantly above that of December, January and February; July was significantly better than November, December, January, February, March and September; and December was significantly below all other months. Grouping the months into seasons (table 1) showed that spring and summer semen had a significantly higher motility than fall and winter semen. The difference between fall and winter semen was not significant, and spring and summer semen did not differ significantly in initial motility. The semen collected during the warm months definitely had more vigorous motility than that collected during the cold months of fall and winter.

Maintenance of useful motility in storage. The storing ability of the undiluted semen showed significant difference among the bulls and among the months. With $p = 0.01$ representing the level of significance, the storage time of December was significantly below July, September, October, and November; July, October, and November were significantly above February;

and, October and November were significantly above March. When $p = 0.05$ was taken as the significant point, December and February storage was significantly below that of April, July, September, October and November; and February, March, May and December were significantly below October and November. When the months were grouped into seasons, the average storage time of the winter months was significantly lower than that of the summer and fall months, but the differences between winter and spring months may have occurred as a result of chance 1 out of 20 times. The storing ability of the semen was markedly depressed by the cold months, December to March, and it improved in general after that time to reach its peak in late summer and early fall.

Abnormal spermatozoa. The differences in abnormal sperm production among bulls were highly significant. The variation among the bulls was so great that the small differences among the months were not significant. The greatest percentage of abnormal sperm was produced in summer and the least in the fall. Grouping the months into seasons made the difference between summer and fall on the borderline of significance ($p = 0.05$). The other seasons did not differ significantly from each other in any combination, hence the importance of the difference observed between morphology of summer and fall semen is considered to be very slight.

DISCUSSION

The most significant seasonal change in the average semen quality of the bulls studied was a decrease in initial motility and viability and an increase in pH with the onset of cold weather in December. These indications of poorer quality semen were probably due to the poorer physical vigor or inadequate sexual stimulation of the old bulls in cold weather. These changes were confined almost entirely to the bulls which were over four years old. The semen from young bulls was as good in motility and viability in December and January as it was in June and July. Since the ejaculates from young bulls were a small minority in this study, however, the averages exhibit more nearly the picture presented by older bulls. Erb *et al.* (4) also have noted the deleterious effect of very cold weather upon semen quality. Since proved bulls which are to be used widely in artificial inseminating work will usually be fully as aged as the bulls used in this study, the results secured should be borne in mind in caring for them. The breeding chute and collection stall at the University of Missouri are out in the open, unprotected from the elements. The bull sheds are three-sided structures, open to the east. The old bulls were noticeably less vigorous and less eager to serve during cold weather than during warm weather and were somewhat "crampy" in winter. It is probable that greater attention to the comfort of the aged sires would result in improved quality of the winter semen.

The drop in semen quality in summer observed by Erb *et al.* (4) and Anderson (1) did not occur. The heat of summer apparently did not ad-

versely affect spermatogenesis in these bulls. In fact, excellent quality semen was obtained regularly from all bulls during the warmest season. These results concur with the observations of Weatherby *et al.* (11) and Lasley (7). The only indication of a poorer quality of sperm produced in summer was the increased abnormal forms produced in July. Since the percentage of abnormal sperm decreased during August and September, also hot months, it does not seem logical to correlate the increase observed in July with temperature.

It was also observed, in confirmation of Erb's (4) observations, that the volume of the ejaculate and the concentration of spermatozoa were slightly lower in summer than in other seasons. The differences were not statistically significant, however; and it is believed that the decreases were not an indication of lowered spermatogenesis or fertility. Motility and viability of the spermatozoa which are closely correlated with fertility, were above average in the summer months.

The low pH for July was due to a few early determinations in that month which were made on semen which had not been cooled promptly. The air temperature was so high that the metabolism of the sperm was kept at a high rate with a resulting high acid production. It is believed that a larger body of data secured under as uniform controlled condtions as those for August and the following months would not show pronounced monthly variations in semen pH. Anderson (2) did not find a significant monthly variation in the pH of bull semen.

Considering altogether the six characteristics of bull semen which have been discussed, it does not seem that spermatogenesis in the dairy bull is significantly affected by season. Furthermore, in the young, vigorous bulls under observation no important seasonal effects were observed. The aged bulls seemed to suffer more from cold weather than the younger bulls and showed less sexual drive or vigor in winter. The general lowered physical vigor possibly was reflected in decreased vitality of their spermatozoa. It seems probable, therefore, that season as such may have no important effect upon the semen quality of dairy bulls in Missouri. Environmental conditions that may adversely affect the physical comfort or even the vitality or health of the bull, however, may result in the production of poorer quality semen. The effect of the observed seasonal differences in semen quality upon fertility of bulls used for natural service or for artificial insemination with non-stored semen would probably be insignificant because of the slight difference in conception rate which has been demonstrated between medium and high quality semen (10). Dawson (3) found no significant seasonal differences in the fertility of aged sires from widely distributed stations in the United States used for natural service. Where artificial insemination practices requiring regular collection and storage of high quality semen are followed, the effect of extreme weather conditions

or other factors adversely affecting the physical vigor of old bulls may be responsible for varying conception rates.

SUMMARY

A study of the monthly variation of the initial motility, volume, concentration, useful storage time, pH, and morphology of the semen of thirteen dairy bulls used in the University of Missouri herd during three years has been presented. The monthly variations in volume, concentration, and percentage of total abnormal spermatozoa were not statistically significant. The pH of the semen was significantly lower in the summer than in the fall. Initial motility and useful viability were lower in winter than in spring and summer. The results were interpreted as being largely due to the adverse effect of winter weather upon the physical well being and sexual activity of the aged bulls which furnished the majority of the semen studied.

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WHEAT GERM OIL AS AN ANTIOXIDANT IN DAIRY PRODUCTS

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The use of antioxidants in the manufacture of food stuffs containing oils and fats has been studied by a number of investigators. Greenbank and Holm (13) found maleic acid, hydroquinone, and certain other phenolic compounds to have antioxidant properties. Chilson (3), Dahle and Palmer (10), and Greenbank (12) reported that the addition of 20 to 100 milligrams of pure vitamin C per liter of milk retarded or entirely prevented the development of an oxidized flavor in susceptible milk to which no copper had been added. Barnicoat and Palmer (2) studied the antioxidant properties of vitamins A, B, C, D, E, F, and nicotinic acid and found that only vitamins C and E were effective.

Gÿorgy and Tomarelli (14) found corn, oats, wheat, rice, bran extract and Avenex to have high antioxidant properties. Of the known B vitamins, p-aminobenzoic acid was the only one they found to be significantly antioxygenic.

Tracy and Corbett (24) have shown that the addition of 0.1 to 0.25 per cent sodium citrate retarded the development of oxidized flavor in milk. Anderson (1) found that a pancreatic extract when added to milk protected it from developing an oxidized flavor.

The work of Dahle and Josephson (6, 7, 8), Corbett and Tracy (4), Koenig (17), Maack and Tracy (18), Mueller and Mack (20), and Peters and Musher (23) has shown that the use of oat flour or a water extract from the oat flour prevented or retarded the oxidized flavor development in milk, ice cream, frozen cream, and butter. Mueller and Mack (21) in studying the antioxidative properties of several cereal flours found that whole oat flour, finely milled oat flour, and corn flour were of equal value but that wheat, barley, rye, and rice flours had but little antioxidative effect.

Corbett and Tracy (5) reported the effectiveness of tyrosine, tyrosine esters and the water extract of certain cereal flours as antioxidants in dairy products. Hollender and Tracy (15) experimented with the use of certain antioxidants in powdered whole milk. Among the antioxidants they found most effective were gum guaiac, hydroquinone, ascorbic acid and sodium citrate.

The studies of McFarlane of MacDonald College, Quebec, as reported by correspondence with the author, have shown wheat germ oil to have antioxi-

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dant properties when added to certain animal and vegetable fats and oils used in the manufacture of shortening. The results were measured by means of the Swift's stability test. This investigator also found wheat germ oil particularly when fortified with citric acid retarded oxidative changes in powdered whole milk as measured by the peroxide value. McFarlane finds wheat germ oil to be more effective than either hydroquinone or gum guaiac.

Realizing the importance of copper contamination in the development of the oxidized flavor, modern dairies use stainless steel in the construction of their equipment wherever possible. In spite of this and other precautions that are taken to retain a normal flavor in the stored products, the industry still recognizes oxidized flavor development in dairy products as a serious problem. This is particularly true in the case of powdered whole milk, much of which is likely to be stored for some time at high temperatures (70° – 125° F.) before consumption. Because of the important part that powdered whole milk plays in the dietary of our armed forces as well as that of the civilian population of our allies, it seems that serious consideration should be given to the application of all known methods that will lengthen the shelf life of the product. Since any oxidation process to which the fat is subjected is likely to result in the destruction of certain of the vitamins contained in milk (Pavcek and Shull (22)), it would also seem desirable from a nutritional point of view to add harmless antioxidants to those dairy products that are to be stored for some time before consumption.

EXPERIMENTAL DATA

The use of solvent extracted wheat germ oil as an antioxidant in milk, frozen cream, and powdered whole milk made by both the spray and roller methods has been studied. Representative results are given.

Use of wheat germ oil in pasteurized milk. An attempt was first made to determine to what extent wheat germ oil would retard the development of an oxidized flavor in unhomogenized whole milk. The wheat germ oil was added at three levels, 0.1, 0.2, and 0.3 per cent of the weight of the fat. The oil was mixed with the cold milk before pasteurization (143.5° F., 30 min.). The milk used was produced in late spring (May). To a portion of the milk, copper was added at the rate of 1 ppm. and 2 ppm. After 24 hours storage at 40° F. the samples were judged for flavor. The results are given in table 1.

A definite retardation of oxidation was evident in those samples containing the wheat germ oil and to which copper had been added. No particular benefits were obtained at levels higher than 0.2 per cent of the wheat germ oil. The best flavor was in the samples containing no added copper to which 0.1 per cent of wheat germ oil was added. At the 0.2 and 0.3 per cent level enough of the wheat germ oil flavor was noticeable to cause the milk to score less than the control.

TABLE 1

Wheat germ oil (A) as an antioxidant in whole milk

Sample	Flavor score* after 3 days' storage at 40° F.	
	Score	Criticism
Control	36	Sl. bitter
Control + 0.1% W.G.O.	37	Sl. oil flavor
Control + 0.2% W.G.O.	35	Sl. oil flavor
Control + 0.3% W.G.O.	34	Sl. oil flavor
Control + 1 ppm. Cu	29	Oxidized
Control + 1 ppm. Cu + .1% W.G.O.	31	Oxidized
Control + 1 ppm. Cu + .2% W.G.O.	32	Oxidized
Control + 1 ppm. Cu + .3% W.G.O.	32	Oxidized
Control + 2 ppm. Cu	28	Oxidized
Control + 2 ppm. Cu + .2% W.G.O.	31	Oxidized
Control + 2 ppm. Cu + .3% W.G.O.	31	Oxidized

* Basis of 45 as perfect score.

In other experiments it was found that at levels higher than 0.3 per cent of the weight of the fat the wheat germ oil flavor was sufficiently detectable in the milk to be objectionable even when copper was present.

Use of wheat germ oil in frozen cream. To study the effect of wheat germ oil in retarding the development of oxidized flavor in frozen cream, cream containing 50 per cent fat was mixed with sufficient sucrose to produce a sugar content of 12 per cent. Half of this sweetened cream was pasteurized at 160° F. for 30 minutes and the other half at 170° F. for 15 minutes. To half of each of the two lots 0.5 ppm. of copper was added. To a portion

TABLE 2

Wheat germ oil (A) as an antioxidant in frozen cream

Sample*	Degree of oxidized flavor after			
	4 mo.	6 mo.	9 mo.	13 mo.
A—Cream pasteurized at 160° F. for 30 minutes				
1A – Control	–	–	–	2½+
1B – Control	+	+	6+	7+
2A + 0.2% W.G.O.	–	–	–	–
2B + 0.2% W.G.O.	–	+	2+	4+
3A + 0.3% W.G.O.	–	–	–	–
3B + 0.3% W.G.O.	–	?	½+	3+
B—Cream pasteurized at 170° F. for 15 minutes				
1A	–	–	–	–
1B	–	–	+	5+
2A + 0.2% W.G.O.	–	–	–	–
2B + 0.2% W.G.O.	–	–	½–	2½+
3A + 0.3% W.G.O.	–	–	–	–
3B + 0.3% W.G.O.	–	–	?	2

* A = no copper added.
B = ½ ppm. Cu added.

of each of the four lots wheat germ oil at two levels (0.2 and 0.3 per cent of the weight of the fat) was added. The samples were stored in quart Sealright containers in an ice cream hardening room and were judged every 3 to 4 months over a period of about 13 months. The results given in table 2 show that wheat germ oil caused a definite retardation of the oxidation of butterfat when copper was present. It is also evident that heating cream above 160° F. (170° F.) during pasteurization also aided in retarding oxidation. This confirms the results of Trout and Scheid (25) as well as Dahle, Lawhorn, and Barnhart (9), and McFarland and Burgwald (19). The beneficial effect of the higher heat treatment has been found by Gould and Sommer (11) and Josephson and Doan (16) to be due to the production of sulfhydryls which are reducing substances. Best results were obtained when both the wheat germ oil and the high heat treatment were used. The superior effect of the combination was noticeable, however, only after nine months of storage.

Wheat germ oil as an antioxidant in powdered whole milk. Preliminary studies having established the antioxidant properties of wheat germ oil in milk and cream it was desired to determine to what extent the substance would function in powdered whole milk. A complete understanding of the nature of the ingredient contained in wheat germ oil that is responsible for the antioxidant properties is lacking. It is thought, however, that the tocopherols and phosphatides that are present are contributing agents. Since the start of this study it has been found that the potency of wheat germ oil can be increased by the addition of citric acid. The use of sodium citrate as an antioxidant in milk has been previously studied by Tracy and Corbett (24). Three different oils[1] were used, formula A—regular wheat germ oil, formula C—regular wheat germ oil plus 2 per cent citric acid, and formula D—regular wheat germ oil plus 5 per cent citric acid and 30 per cent soybean lecithin.

Procedure followed in preparing milk powder samples. Powdered whole milk prepared by both the vacuum roll and spray processes was used to test the antioxidant properties of the wheat germ oil. The milk used for the roller drying was produced by the University herd, while that spray dried was received at a commercial condensery. An attempt was made to handle the milk in such a manner as to minimize copper contamination.

The powder was packed in number 2 cans in the case of the roller process and number 1 cans in the case of the spray drier. Paper containers were used in one of the experiments with spray powder (samples 5019 and 5020—table 4). One set of the spray powders was packed plain and one set was packed in nitrogen.

The milk used to make the powder manufactured by the roller method (table 3) was preheated at 170° F. for 30 minutes and concentrated to ap-

[1] The wheat germ oil used in this study was solvent extracted and was supplied by the VioBin Corporation, Monticello, Illinois.

proximately 38 per cent total solids. Wheat germ oil—formulas A, C, and D, were added to the condensed milk at the rate of 0.2 per cent of the weight of the fat in trial 1 and 0.1 per cent in trial 2.

In the case of the spray dried samples 4924–31 and 4952–59 (table 4) the wheat germ oil was added to skim milk that had been heated to 170° F. and homogenized at 2,500 pounds pressure. This emulsion was then added to the raw milk and held over night. The milk was preheated at 180° F. for 7 minutes, cooled to 145° F. and then condensed. It was homogenized at 3,000 pounds at 130° F. The drying was then done 24 hours later. The nitrogen-packed powder was first subjected to a vacuum of 2 mm. Then CO_2 was introduced to 10 pounds pressure for 10 minutes, then a vacuum of 2 mm. was drawn, then nitrogen was introduced to a pressure of 5 pounds for 10 minutes.

TABLE 3

Use of wheat germ oil in roller (vacuum) process powdered whole milk

Sample	Trial	Flavor score		
		Fresh	3 mo.	6 mo.
Control	1*	38	29	29
Control + 0.2% W.G.O. A	1	38	33	32
Control + 0.2% W.G.O. C	1	38	34	32
Control + 0.2% W.G.O. D	1	38	34	33
Control	2†	38	37	33
Control + 0.1% W.G.O. A	2	38	36	35
Control + 0.1% W.G.O. C	2	38	37	35
Control + 0.1% W.G.O. D	2	38	37	36

* Prepared Nov., 1942.
† Prepared Feb., 1943.

Samples 4887–90 and 5017–22 were prepared in the same manner as those above except that nitrogen only was used in the case of the gas-treated lot.

The only variation in the procedure followed in the preparation of samples 4985–88 from that followed in the preparation of sample 4887–90 was the method of adding the wheat germ oil. Formula D was used in all samples. In the case of samples 4985 and 4986 the oil was homogenized in skim milk and added to the whole milk before condensing as outlined above. In the case of samples 4987 and 4988 the oil was mixed with the condensed milk just before spraying.

The dried milk samples were judged when fresh and every 2 to 3 months during storage at room temperature. In table 4 only the final flavor scores are reported. The flavor of the reconstituted samples was 38–39 at the beginning of the experiment and was criticized as being cooked. Subsequent scorings were made on the basis of the degree of oxidized flavor developed. The samples were reconstituted by mixing 30 grams of the powder with 200 ml. of tap water using an electric malted milk machine. The sample cans were opened immediately before the milk was reconstituted.

TABLE 4

Use of wheat germ oil in spray dried whole milk powder

Sample		Preheat temp. before condensing	Conc. of solids	Spray temp.	Spray pressure	Spray chamber temp.	Temp. of powder when packed	Type of pack*	Sol. index	H_2O	Wheat germ oil used	Gas content†		Flavor score Aug. 7, 1943
No.	Date made											CO_2	O_2	
			%	°F.	lbs.	°F.	°F.		cc.					
4924	11/24/42	180° F. 7 min.,	11.42 F.	115	2,000	170	106	P	0.1	2.1	None			30
4925	11/24/42	cooled to 145° F.	38.26 T.S.	115	2,000	170	106	N	0.1	2.1	None	3.64	4.24	32
4926	11/24/42		11.19 F.	115	2,100	170	106	P	0.1	2.3	0.1% A			31
4927	11/24/42		37.94 T.S.	115	2,100	170	106	N	0.1	2.3	0.1% A	3.81	3.5	33
4928	11/24/42		10.91 F.	115	2,300	170	102	P	0.1	2.0	0.1% C			31
4929	11/24/42		36.82 T.S.	115	2,300	170	102	N	0.1	2.0	0.1% C	4.17	3.15	33
4930	11/24/42		11.01 F.	115	2,400	170	102	P	0.1	2.0	0.1% D			31½
4931	11/24/42		37.41 T.S.	115	2,400	170	102	N	0.1	2.0	0.1% D	3.21	3.75	34
4952	12/ 2/43	180° F. 5 min.	11.44 F.	115	1,800	170	104	P	0.1	1.9	None			29
4953	12/ 2/43		38.64 T.S.	115	1,800	170	104	N	0.1	1.9	None	3.16	3.99	31
4954	12/ 2/43		11.28 F.	115	1,800	170	106	P	0.2	1.95	0.05% A			30
4955	12/ 2/43		36.93 T.S.	115	1,800	170	106	N	0.2	1.95	0.05% A	4.09	3.68	31½
4956	12/ 2/43		11.05 F.	115	1,800	170	106	P	0.1	1.60	0.05% C			30
4957	12/ 2/43		37.47 T.S.	115	1,800	170	106	N	0.1	1.6	0.05% C	3.25	3.65	31½
4958	12/ 2/43		10.98 F.	115	2,400	170	107	P	0.1	1.4	0.05% D			30
4959	12/ 2/43		36.50 T.S.	115	2,400	170	107	N	0.1	1.4	0.05% D	2.76	3.54	32
4887	11/10/42	170° F. 30 min.	11.59 F.	130	2,500	165	122	P	0.1	2.0	None			23
4888	11/10/42		37.60 T.S.	130	2,500	165	122	N	0.1	2.0	None	0.25	3.54	30
4889	11/10/42		11.47 F.	130	2,400	170	130	P	0.1	2.0	0.1% A			25
4890	11/10/42		37.53 T.S.	130	2,400	170	130	N	0.1	2.0	0.1% A	0.20	3.20	30
4985	12/12/42	180° 5 min.,	10.90 F.	130	2,500	170	90	P	0.15	2.1	0.1% D			33
4986	12/12/42	cooled to 145	38.56 T.S.	130	2,500	170	90	N	0.15	2.1	0.1% D	3.09	4.05	35
4987	12/12/42		10.87 F.	130	2,500	170	90	P	0.20	2.8	0.1% D			34
4988	12/12/42		38.35 T.S.	130	2,500	170	90	N	0.20	2.8	0.1% D	3.66	4.42	36
5017	1/13/43	170° F. 30 min.	10.06 F.	65	800	180	64	P–tin	0.10	1.8	None			32
5018	1/13/43		36.14 T.S.	65	800	180	64	N	0.10	1.8	None	0.28	1.45	35
5019	1/13/43			65	800	180	64	P–paper	0.10	1.8	None			33
5020	1/13/43		10.40 F.	65	800	180	63	P–tin	0.10	2.0	0.1%			34
5021	1/13/43		37.65 T.S.	65	800	180	63	N	0.10	2.0	0.1%	0.22	1.75	36
5022	1/13/43			65	800	180	63	P–paper	0.10	2.0	0.1%			36

* P = plain.
N = gas.

† Lots 5018 and 5021 were packed with water pumped nitrogen, while the other lots were packed with oil pumped nitrogen.

Other details regarding the procedure followed in making the spray powders are given in table 4.

Milk powder data. The data obtained on the effect of wheat germ oil upon the keeping quality of powdered whole milk are given in tables 3 and 4. It is evident that wheat germ oil retarded the oxidation of butter fat but did not prevent its occurrence. The oil treated with citric acid was slightly superior to the untreated oil. Formula D gave results somewhat better than those obtained with Formula C in most cases. The method of adding the oil was of no particular importance. The oil functioned in both plain and nitrogen-packed powder. It should be pointed out that neither the use of wheat germ oil or gas packing prevented oxidation from taking place though packing in the presence of an inert gas proved to be somewhat more beneficial than the use of the wheat germ oil without gassing. Best results were obtained with a combination of the two, however.

SUMMARY AND CONCLUSIONS

The ability of wheat germ oil to prevent oxidation has been determined in fluid milk, frozen cream and powdered whole milk made by both the vacuum roll and spray processes. The amount of wheat germ oil needed for best results is approximately 0.2 per cent of the weight of the fat. At higher levels (0.3 per cent) the flavor of the oil is sometimes detectable. Wheat germ oil reinforced with citric acid was found to be more effective in retarding oxidation in milk powder than regular oil. While wheat germ oil is not as effective as gas packing with nitrogen in preventing the development of the oxidized flavor in powdered milk, a combination of the two will prolong the shelf life of the powder more than either one alone will accomplish.

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TENTATIVE PROGRAM
AMERICAN DAIRY SCIENCE ASSOCIATION MEETING

TUESDAY, JUNE 20, 1944

Morning Session

9:00–12:00—General Meeting.
Welcome.
Response and presidential address—PRESIDENT A. C. DAHLBERG.
Address by guest speaker.

Afternoon Session

1:00– 4:00—Sectional Meetings—Extension Section, Manufacturing Section, and Production Section.
4:00– 5:00—Committee Meetings—Extension Section, Manufacturing Section, and Production Section.

Evening Session

Production Section Tentative Symposium.

WEDNESDAY, JUNE 21, 1944

Morning Session

9:00–11:00—Sectional Meetings—Extension Section, Manufacturing Section, and Production Section.
11:00–12:00—Joint Business Meeting of the Production Section and the Extension Section.
—Business Meeting of the Manufacturing Section.

Afternoon Session

1:00– 4:00—General Session—Post War Problems in Dairying.
Introductory Speaker.
From the Extension View Point.
From the Production View Point.
From the Manufacturing View Point.
4:00– 5:00—Committee Meetings—Extension Section, Manufacturing Section, and Production Section.

THURSDAY, JUNE 22, 1944

Morning Session

9:00–11:00—Sectional Meetings.
Manufacturing Section Symposium—Dehydrated Milk and Milk Products.

Joint Symposium—Production and Extension Sections.

9:00– 9:15—Mastitis (from the dairyman's standpoint), T. S. SUTTON, Ohio State University.

9:15– 9:45—Modern methods of treating mastitis, C. S. BRYAN, Michigan State College.

9:45–10:15—Discussion.

10:15–10:45—The feed situation, MR. WALTER BERGER, Chairman of the Feed and Livestock Division, Food Production Administration.

10:45–11:00—Discussion of feed situation.

11:00–12:00—Sectional Business Meetings—Extension Section, Manufacturing Section and Production Section.

Afternoon Session

1:00– 3:30—Latin American Dairying.
WILLIAM S. HENDRIX, Ohio State University.
R. E. HODGSON, United States Department of Agriculture.
A. C. DAHLBERG, Cornell University.

3:30 —General Business Meeting.

Evening Session

6:30 —Annual Banquet.

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Industrial and Engineering Chemistry

Journal of Agricultural Research
Journal of Agricultural Science
Journal of American Medical Association
Journal of American Veterinary Medical Association
Journal of Animal Science
Journal of Bacteriology
Journal of Biological Chemistry
Journal of Dairy Research
Journal of Dairy Science
Journal of Endocrinology
Journal of Experimental Medicine
Journal of General Physiology
Journal of Genetics
Journal of Heredity
Journal of Industrial and Engineering Chemistry
Journal of Infectious Diseases
Journal of Milk Technology
Journal of Nutrition
Journal of Pathology and Bacteriology
Journal of Physical Chemistry
Journal of Physiology
Journal of Veterinary Research

Lancet
Le Lait

Milk Dealer
Milk Industry
Milk Plant Monthly

National Butter and Cheese Journal
New Zealand Journal of Science and Technology

Oil and Soap

Pacific Dairy Review
Proceedings of Society of Experimental Biology and Medicine

Refrigerating Engineering

Scientific Agriculture
Southern Dairy Products Journal

SPECIAL PUBLICATIONS

Federal Dairying and Bacteriological Establishment, Liebefeld, Berne, Switzerland

International Association of Ice Cream Manufacturers
International Association of Milk Dealers

National Institute for Research in Dairying, Reading, England
New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BACTERIOLOGY

127. Further Studies on Coliform Bacteria Serologically Related to the Genus *Salmonella*. P. R. EDWARDS, W. B. CHERRY, AND D. W. BRUNER, Ky. Agr. Expt. Sta., Lexington. Jour. Infect. Dis., *73*, No. 3: 229–238. Nov.–Dec., 1943.

In a continuation of work reported earlier (Jour. Dairy Sci., *25*, No. 6: A144. June, 1942) the serological properties of 44 coliform cultures were studied. All of the cultures studied were considered pathogenic. An antigenic analysis revealed that the 44 cultures were divisible into 14 serological types and these types were divisible into 11 somatic groups. With the exception of 3 cultures, the H antigens of all of the types resembled those of *Salmonella düsseldorf* and *S. cerro*. The H antigens of the other 3 cultures resembled those of *S. enteritidis*. Antigenic formulas, based in part on the Kaufmann-White schema for the salmonellas, are given for the 14 types.

J.F.C.

CHEESE

128. Consistency of Cheese Curd at Pitching and Grinding. F. M. V. COPPEN. Dairy Indus., *8*, No. 9: 488. Sept., 1943.

The author discusses a number of control tests which are employed at different stages in Cheddar cheese manufacture. Data are given and the relative merits of these tests presented. D.V.J.

129. Oil Separation in Processed Cheese. J. L. PALMER and W. H. SLY. Dairy Indus., *8*, No. 8: 427. Aug., 1943.

In the manufacture of processed cheese much can be done to avoid oil separation during storage and distribution. It is pointed out that the ripeness of the cheese used for processing is a very important factor. Very ripe cheese frequently results in loose, grainy and oiled-off processed cheese while very fresh cheese produces a stable emulsion.

The stabilizing salt (called melting salt in England) is also a very important factor and according to these authors sodium citrate alone or a suitable blend of sodium citrate and phosphates produce the best results. Sodium metaphosphate is of questionable value. When the pH of a processed cheese is over 5.8 to 6.0 or below 5.4, there is more danger of oil separation. It is also pointed out that prolonged or violent agitation resulting in aeration will have a tendency to break down the emulsion. A continuous process is more desirable than a batch system. D.V.J.

DISEASE

130. **Studies on Epidemic Diarrhea of the New-Born: Isolation of a Filtrable Agent Causing Diarrhea in Calves.** JACOB S. LIGHT, M.D., AND HORACE L. HODES, Lt. MC, USNR, Johns Hopkins Univ. and Sydenham Hosp., Baltimore City Health Dept., Baltimore, Md. Amer. Jour. Pub. Health, *33*, No. 12: 1451–1454. 1943.

In connection with four separate epidemics of diarrhea of the new-born a filtrable agent has been isolated which regularly produces diarrhea in calves. In the attempts so far made, this agent has not been isolated from the stools of normal infants or normal calves. The evidence suggests, though it is not conclusive, that the agent may be a cause of epidemic diarrhea of the new-born. M.W.Y.

131. **Use of Modern Laboratory Aids in the Investigation of a Typhoid Fever Outbreak.** EDWARD R. SCHLESINGER, Asst. Dist. Health Officer, N. Y. State Dept. Health, Albany, N. Y. Amer. Jour. Pub. Health, *33*, No. 10: 1257–1262. 1943.

An outbreak of 27 cases of typhoid fever is described which occurred in Oswego County, New York, in 1941 and 1942. Twenty-three of the cases were probably due to the ingestion of curd or fresh cheese at a local factory or were secondary to such cases. The cases occurred over a period of 17 months. Bacteriophage typing separated the type C cases, due to the contaminated curd and cheese from type A cases traced to food prepared by two type A typhoid carriers. Two typhoid carriers were found among the dairy farmers supplying the cheese factory. Typing showed one to be type C and eliminated the other as the possible source of the outbreak, despite the fact that epidemiological evidence alone pointed more forcefully to the latter as the carrier responsible for the outbreak. M.W.Y.

132. **What Is Known on Undulant Fever.** K. G. WECKEL, Assoc. Prof. of Dairy Indus., Univ. Wis. Milk Plant Monthly, *32*, No. 7: 41–42. 1943.

The disease "undulant" fever, deriving its name from its characteristic of recurring at intervals or in cycles, is known also as Brucellosis, intermittent typhoid, Malta or goat fever or subcontinuous fever depending in part on locality and observations. The disease has its origin in animals. The bacteria responsible for it among cattle is known as *Brucella abortus;* among sheep and goats as *Brucella melitensis;* and among swine as *Brucella suis.* Any type may cause undulant fever in man but that from *Brucella melitensis,* which has seldom been diagnosed in man in the United States, is the most fatal. *Br. abortus* are discharged through uterine secretions or, when the udder tissue is infected, through the milk. Humans consuming

raw milk may contract the disease but relatively this seldom occurs. The eradication program has reduced the incidence of the disease to a low of probably 2% or less. Three general methods are used in eradication: (1) Test and slaughter, (2) Test and segregation, and (3) Calfhood vaccination.

The incidence of undulant fever in humans is greatest among handlers of livestock and slaughterhouse or meat packing plant employees. The disease among humans is not contagious. There have been but very few recorded outbreaks of Brucellosis traced to milk and those to raw milk. No outbreaks have been reported from consuming pasteurized milk. Hence, the program of eradication and pasteurization minimizes the economic loss caused by the disease on farms and assures the consumer of a safe milk supply. G.M.T.

FEEDS AND FEEDING

133. Physiological Requirements and Utilization of Protein and Energy by Growing Dairy Cattle. E. G. Ritzman and N. F. Colovos. N. H. Agr. Expt. Sta. Tech. Bul. 80. 59 pages. Aug., 1943.

An intensive study on the energy and protein requirements for growth of dairy cattle, from birth to approximate maturity. Eleven pure bred Holstein heifers were used in the following age groupings: Birth to 4 months, 3 heifers; 4–36 months, 4 heifers; 8–27 months, 4 heifers.

This bulletin lacks an adequate summary and it is difficult at times for the reader to distinguish between conclusions drawn from original data, and statements based on other work having a bearing on the results. The following statements, for the most part direct quotations, have been selected as being of particular significance.

A very close agreement was found between individuals in their basal metabolism at approximately the same age. A high pitch of tissue activity prevailed for about a week after birth; this was followed by a sudden drop, after which further decline was quite steady and gradual. This declining rate in tissue activity was reflected by a periodical decline in growth rate as indicated by daily gains in live weight in relation to total weight of the individual.

Certain of the results demonstrated the critical importance of the time factor in growth. Aging is almost purely a question of time, and maturity is reached in the span allotted for the species whether food is scarce or abundant.

An offshoot from the main investigation was a study of the effect of accessory illumination on metabolism. The conclusion that seemed most probable was that any effect of visual light on metabolism is immediate and prevails only as long as the (nerve) exciting effect of light is present.

The biological value of protein depends not only on the character of its nitrogenous constituents, or on the level of the protein intake, but also on

the physiological adaptability of the individual to utilize it. . . . The true measure of value of a feed for a given purpose must be determined by the individual which uses it most efficiently. The results do not suggest any beneficial results from the so-called associative effects of protein from different sources, but rather a low order of biological value of cereal proteins for growth.

Protein utilization values secured indicate that the protein of hay had a surprisingly high value for growth (practically the same as grain); that corn had a low value, that linseed meal was somewhat better than cottonseed meal, and that barley was about equal to oats.

Efficiency of protein utilization was determined as much by the inherent growth rate potential of the individual as by the available supply of food protein.

Relatively great differences may exist in protein utilization between individuals of similar age and type or breed, and maintained under like conditions.

The comparative uniformity of the decline in protein conversion indicates that it is impossible to force growth beyond these declining inherited limits.

The influence of hereditary limitations to storage of protein for growth appears to be the deciding factor as to the form in which available food energy in excess above maintenance is stored by the body.

Quantitative statements of requirements of protein and energy appear in detail in a series of tables which do not lend themselves to a simple summary statement. The reader is therefore referred to the original article for further specific information.

17 tables, 43 literature references. J.G.A.

134. Meeting the Protein Requirements of Dairy Cows. H. B. Ellenberger. Vt. Agr. Expt. Sta. Pamphlet No. 1. 12 pages. March, 1943.

A non-technical discussion of the subject in the light of the present protein shortage. The need for good pasture supplemented by a simple grain mixture such as corn and oats, is stressed. The writer's opinion is that during the present emergency a concentrate mixture containing not more than 16% protein, if liberally fed, should serve most dairy needs, including winter feeding. The importance of storing ample supplies of roughage of the highest possible quality is strongly emphasized. J.G.A.

FOOD VALUE OF DAIRY PRODUCTS

135. Milk in the National Food Program. W. E. Krauss, Chief, Dairy Dept., Ohio Agr. Expt. Sta., Wooster, O. Milk Plant Monthly, *32*, No. 9: 34. 1943.

Emergency food problems involve an adequate supply of calories, pro-

tein, minerals and vitamins from sources people have been accustomed to using and in keeping with the agricultural system which makes efficient use of land labor and feed. In 1942, about 40% of the food energy, 57% of the protein and 73% of the fat were from livestock products. Three-fourths of the calcium and about one-half of the riboflavin in the civilian food supply were from milk products. Considering the output of calories and protein from concentrates fed, the utilization of labor for the production of protein, the protein obtained per acre, the minerals and vitamins, milk ranks at the top followed closely by eggs. Milk and egg production are, therefore, emphasized. Indications are that the demand for milk may be maintained or even increased. G.M.T.

136. Chemical and Biological Stability of Crystalline Vitamins D_2 and D_3 and Their Derivatives. W. HUBER AND O. W. BARLOW, Res. Labs., Winthrop Chem. Co., Inc., Rensselaer, New York. Jour. Biol. Chem., *149*, No. 1: 125. July, 1943.

All forms of Vitamin D, including Vitamin D_2 (irradiated ergosterol) in a crystalline form, or when absorbed on casein (ertron), Vitamin D_3 (activated 7-dehydrocholesterol), as well as Vitamin D from natural sources, are susceptible to destruction through oxidation as shown by changes in their melting points and specific rotations. This decomposition is more rapid when they are stored in the dry form rather than as emulsions. The various nitrobenzoic acid esters of Vitamins D_2 and D_3 are more stable for they showed no apparent decomposition after being stored for five years.

When an emulsion of Vitamin D_2 in propylene glycol (drisdol) was diluted with water it lost as much as 75% of its potency during the period of bioassay, but when diluted with milk or propylene glycol it showed no deterioration.

Market milk fortified with Vitamin D_2 showed no apparent loss of potency when held for 8 days and evaporated milk, similarly fortified, showed no loss of Vitamin D after storage periods ranging from 6 to 15 months. A.O.C.

137. Some Medical Aspects of Protein Foods. FREDRICK J. STARE AND GEORGE W. THORN, Schools of Pub. Health and Medicine, Harvard Univ.; Med. Serv., Peter Bent Brigham Hosp., Boston, Mass. Amer. Jour. Pub. Health, *33*, No. 12: 1444–1450. 1943.

The protein requirement of man cannot in the present state of knowledge be quantitatively stated in terms of amino acids, under certain standardized conditions. Calorie intake from carbohydrate and fat spares protein, and in the presence of sufficient calories from non-protein sources, the amount of protein in the diet of an active adult may be safely reduced to 50 grams per day, of which as little as 5 grams may be in the form of animal protein.

The protein requirement is not increased in exercise, and physical fitness and efficiency are not impaired or improved on low protein diets adequate in other nutrients. Substituting protein for some of the carbohydrate in the common American breakfast is a feasible way to prevent mid-morning symptoms of fatigue. High protein diets are not harmful to the normal adult and are of definite therapeutic value in many diseases and particularly in convalescence. Certain less common protein foods exist which are of high nutritional value, and which could be used with considerable value in post-war feeding operations. Protein foods are excellent sources of nutrients other than proteins, and we cannot reduce the protein of a diet unless at the same time we provide the other essential factors contributed by protein foods. M.W.Y.

MILK

138. The Place of the Dairy Industry in Postwar America. CHRIS L. CHRISTENSEN, Vice Pres., The Celotex Corp. Milk Dealer, *33*, No. 4: 70–71. Jan., 1944.

Fluid milk production and distribution as a postwar product will experience many changes. Standardization of milk inspection laws and regulations; economies in transportation both from farm and to consumer and the possible inauguration of partial condensation by milk plants before delivery to consumers are postwar changes in the processing field. In the production field (1) improved feeding methods of both hay and grain by use of recommended feeding procedures to improve quality and nutrition of milk as well as quantity; (2) improved soil and soil cultivation methods; (3) use of commercial nitrogen fertilizers for increasing pasture and hay production; (4) herd improvement through use of artificial breeding; (5) improved dairy barns and housing facilities through better designing; and (6) general reduction of milking time and improved equipment will all be factors to consider as a postwar problem in the dairy industry. C.S.T.

139. A Technical Survey of Commercial Cultured Skim Milk or Buttermilk Manufacture in the United States. F. V. KOSIKOWSKY, Dept. of Dairy Indus., Col. of Agr., Cornell Univ., Ithaca, N. Y. Milk Dealer, *33*, No. 4: 25–27, 44–46. Jan., 1944.

A cross-section survey of 45 dairy plants through the United States made by use of questionnaire was basis of this study. A range of from 3,650 to 12.5 million quarts with a total of 25.6 million quarts of cultured buttermilk annually was represented in the survey. Principal factors studied were (1) proportionate relationship of cultured buttermilk to whole milk sold ranging from 1.5 to 14.83% with average of 2.59%; (2) source of starter—88.9% commercial starter used; (3) amount of starter used ranging from

1.28 to 2.17% with average of 1.84%; (4) amount of added milk fat used ranging from 1.00 to 1.69% with average of 1.44%; (5) temperature and range of holding time for pasteurization, temperatures used ranging from 160 to 190° F. for 30 to 37 minutes; (6) temperature and time of incubation ranging from 65° to 75° F. and from 10 to 16 hours held; and (7) acidity of curd when broken, cooled, and stored, ranging from 0.67 to 0.85%. Other factors studied were addition of salt, gelatin, butter, and customer complaints. Wheying-off and viscosity were deemed greatest problems by the author. C.S.T.

140. Addition of Citric Acid to Improve the Flavor of Cultured Buttermilk. J. A. NELSON, Agr. Expt. Sta., Montana State College. Milk Dealer, *33*, No. 4: 32. Jan., 1944.

The addition of citric acid to cultures used in producing cultured buttermilk, similar to use of citric acid in butter cultures, was studied in this experiment. Check sample of milk did not have citric acid added to cultures used but otherwise the samples were processed and treated similarly. The creatin test to determine quantitatively the acetylmethylcarbinol and diacetyl development showed in favor of citric acid cultures. Desirable flavor characteristics in all cultures to which citric acid was added were declared present by two competent culture judges. The author concludes "that the flavor of cultured buttermilk could be improved by the addition of citric acid to the culture milk before inoculation." C.S.T.

141. Agreeable Manner Will Maintain Doorstep Delivery. C. W. ESMOND. Milk Plant Monthly, *32*, No. 8: 29–30. 1943.

The author points out the importance of keeping the milk customer satisfied. Disgruntled milk customers do not really object to curtailment of deliveries; to the prompt return of milk bottles; to the prompt payment of milk bills; to the delivery of uniform quantities of milk daily so as to eliminate returns, or to other reasonable practices approved by good dairy management, but do object to the brusque, abrupt and blunt methods used by some milk men in putting these changes into effect. Since the customer is the ultimate boss not only of the milk men themselves, but of the dairy industry, it behooves the management to insist upon the milk men handling customers with "kid gloves." The customer will continue to prefer doorstep delivery if it is done at reasonable cost, and in an agreeable manner. Agreeable manner in doorstep delivery will not only insure the job of the milk man, but in the end will help to insure the job of all other milk men as well. G.M.T.

142. Dye Reduction Tests for Heat Treated Milk. A. L. PROVEN AND A. ROWLANDS. Dairy Indus., *8*, No. 12: 693. Dec., 1943.

The authors do not recommend the colony count or the coliform test as

a means of controlling the keeping quality of heat treated milk. They suggest a half-hour methylene blue or resazurin test at 37° C. applied to samples which have been stored at 18° C. from 3 P.M. on the day of distribution until 10 A.M. the following day. This method can be relied upon to detect the majority of samples with an unsatisfactory keeping quality.

D.V.J.

143. The Acidity Test Compared with the 10-Minute Resazurin Test and the Methylene Blue Test. G. E. JONES AND H. BARKWORTH. Dairy Indus., *8*, No. 11: 635. Nov., 1943.

A very significant correlation was found between the 10-minute resazurin test and the acidity of milk. The authors observed and presented data to support the fact that the 10-minute resazurin test is more closely affected by changes in acidity than is the methylene-blue test. D.V.J.

144. The Relative Keeping Qualities of Evening, Morning and Mixed Milk. E. W. ERSKINE, B. M. FISCHER, S. M. L. SMITH, AND J. G. DAVIS. Dairy Indus., *8*, No. 11: 618. Nov., 1943.

The authors found no marked differences in the bacteriological qualities of evening, morning and mixed milk. The methods used for this analysis were the "clot on boiling," methylene blue, resazurin, plate count and coli tests. D.V.J.

145. The Use of the Resazurin Comparator in Artificial Light. J. G. DAVIS AND L. G. NEWLAND. Dairy Indus., *8*, No. 10: 555. Oct., 1943.

In reading resazurin tests with the resazurin comparator daylight was found to be most suitable from all standpoints. However, low-pressure mercury vapor fluorescent tubular lamps gave very comparable results but were more fatiguing to the operator's eyes. In using this type of artificial light, it is desirable to exclude other extraneous light. D.V.J.

146. Thermoduric Organisms in Milk. C. S. MORRIS AND M. EDWARDS. Dairy Indus., *8*, No. 10: 550. Oct., 1943.

It is pointed out that heat-resistant types of organisms in milk can usually be traced back to a lack of sanitation on the farm or inefficient cleaning of milk cans at the creamery. Heat resistant coliform organisms may come from dried films on utensils or from contaminated water supplies.

Tests on raw milk are of little value in detecting thermoduric organisms. The author suggests that the pasteurized milk be examined by the following tests: 1. A phosphatase test immediately after pasteurization or when milk arrives at laboratory. Hold the milk for 24 hours at 18° C. and then run,

(a) a plate count at 30° C. or 37° C. on yeastrel milk agar (yeast extract milk agar), (b) a resazurin test at 37° C., and (c) a presumptive coliform test. D.V.J.

147. The Resazurin Test for Sterility of Milk Cans. J. G. DAVIS AND D. W. WATSON. Dairy Indus., *8*, No. 8: 415. Aug., 1943.

The authors attempted several procedures of holding rinse solutions prior to testing them by the standard resazurin technique. Plate counts were used as a basis of comparison. The most satisfactory procedure of those tried was the following: One ml. of rinse is inoculated into 10 ml. of separated milk and incubated at 22° C. in a water bath or large tank in a heated room for 24 hours. At this time a standard resazurin test is made at 37° C. Any sample which reduces to a disc number of 5 or less in 30 minutes is regarded as unsatisfactory and probably has a count of more than 500 per ml. of rinse. D.V.J.

148. Cryophilic Bacteria in Relation to Milk Can Sterility Tests. G. F. V. MORGAN. Dairy Indus., *8*, No. 8: 411. Aug., 1943.

The author found that the cryophilic organisms, isolated from milk cans after mechanical washing, were of a type usually associated with water. He points out that the detergent tank in the can washer frequently is the source of contamination and, therefore, should be cleaned after each day's operation. The rinse tanks on can washers are much less liable to become a problem. However, it is extremely important to keep the entire washer clean if contamination is to be avoided. D.V.J.

149. Rapid Platform Tests. H. BARKWORTH, J. G. DAVIS, J. W. EDGELL, A. ROWLANDS, AND D. W. WATSON. Dairy Indus., *8*, No. 5: 215. May, 1943.

In an attempt to find suitable tests for detecting unsatisfactory milks at the receiving platform, the authors investigated the following methods: smell and taste, clot on boiling, alizarin-alcohol, titratable acidity, pH, resazurin (10 minutes and 1 hour) and methylene blue. Although most of these tests had certain desirable characteristics, the 10-minute resazurin test was found to be most suitable for the purpose. D.V.J.

150. Dye Reduction in Milk Related to Eh, pH and Dissolved Gases. J. M. FRAYER. Vt. Agr. Expt. Sta. Bul. 498. Sept., 1942.

This publication contributes fundamental facts regarding the physiological processes involved in the application of the resazurin and the methylene blue tests for milk quality. The results as summarized are as follows:

"The reduction processes of the resazurin and methylene blue tests were

followed coordinately with Eh, pH and dissolved gas determinations. The results secured seem to warrant the following conclusions:

"1. There is little relationship between the moment of dye reduction and pH, oxygen depletion and pH changes not necessarily proceeding coincidently.

"2. The bacterial growth phase at the moment of test initiation has much to do with the shape of the time: potential curve.

"3. The Eh level at the resazurin-pink stage of reduction is much more variable than it is when fully reduced.

"4. Most milks reduce resazurin to the pink stage at reduced oxygen levels, no case having as yet been observed of complete visual reduction of either dye in the presence of more than a minimum of oxygen.

"5. Milks held at 40° F. or less for 24 more hours tend to attain the resazurin-pink stage at higher Eh levels than when fresh.

"6. It can be safely assumed: (a) that all cell types found in milk have the same influence on dye reduction and gas depletion; (b) that oxygen is the only gas involved in the reaction; (c) that all unusual color modifications result from harmful abnormalities.

"7. The stage at which the carbon dioxide content is significantly increased is often accompanied by a rapid decline in both Eh and pH and by imminent color reduction.

"8. A low count milk sample to which resazurin is added, when exposed to bright sunlight and unaccompanied by metabolic activity previous to incubation, behaves as a rule as does a sample of poor milk in respect to the rapidity of oxygen depletion, of negative Eh swing and of color fading.

"Because of the relatively high sensitivity of the resazurin dye and the possible occurrence of color changes resulting from variations in factors other than those attributable to a high bacterial content and/or to physiological or pathological abnormalities, the opinion is advanced that, in the absence of microscopic confirmation, the methylene blue test for milk quality is likely to afford better results in the hands of the average milk plant operator than are any of the known modifications of the resazurin test."

P.H.T.

151. Mold Growth in Composite Milk Samples. J. M. FRAYER, Vt. Agr. Expt. Sta., Burlington, Vt. Pamphlet No. 2. April, 1943.

Mold growth in composite milk samples is objectionable because certain types of mold elaborate enzymes which may hydrolize fat and consequently may lower the test as much as 0.3 to 0.4%. Mold growth also interferes with adequate sample mixing and pipetting.

To control this problem the mold must be prevented from getting into the sample. This can be done by using clean methods in handling the samples, by thoroughly cleansing all sample bottles, stoppers and storage boxes be-

tween each sampling period, and by adequate germicidal treatment of sample bottles and stoppers. P.H.T.

152. Bi-Monthly or Monthly Testing at Milk Plants. D. W. Whitman, R. O. Slack, and E. O. Herreid, Vt. Agr. Expt. Sta., Burlington, Vt. Vt. Agr. Expt. Sta. Bul. 502. June, 1943.

As a labor-saving measure, composite samples may be tested monthly instead of bimonthly provided the bottles are kept tightly stoppered and are stored at 50° F. or below while not in use. It is also important to keep the samples free from mold growth and to properly prepare the samples for testing. Tests conducted in a commercial milk plant supplied by 113 patrons showed that the bi-monthly composites yielded only slightly more fat than the monthly composites. The preserved composite samples were prepared for testing by warming to 95–100° F. in a water bath at 107–110° F. Any adherent cream was carefully brushed loose. The samples were mixed by pouring four times. After pipetting, the warmed milk was permitted to cool to 70° F. before 15 ml. of sulfuric acid at 70° F. was added to the sample. Mixing of the acid and milk was done in a mechanical shaking device. The tests were read to 0.025% but were recorded to the nearest 0.1%. P.H.T.

PHYSIOLOGY

153. The Effects of Mild Hyperthyroidism on Growing Animals of Four Species. M. Koger and C. W. Turner. Mo. Agr. Expt. Sta. Res. Bul. 377. 75 pages. Sept., 1943.

Growing animals of four species, including mice, rats, guinea pigs, and rabbits, were treated with thyroactive preparations varying in amounts from relatively large dosages which were toxic to very small dosage which apparently did not affect growth or were so small in amount that it appeared impractical to attempt further reduction in dosage.

The growth rate of mice was consistently and significantly increased by treatment with a rather wide range in dosage (0.01 to 0.04 mg. thyroxine-sodium daily or 0.04 to 0.32 per cent thyroactive iodocasein in the ration while maximum size attained by control and treated animals was unchanged. Feed intake of mice was increased by treatment. The treated animals stored more protein and more body weight per unit of feed consumed than controls while control animals were more efficient in storage of fat and energy.

The effect of feeding thyroactive iodocasein to rats was variable with strain and sex. There was some evidence of slight acceleration of growth in weight of a few females due to feeding thyroactive iodocasein, but for the most part body weight was unaffected or depressed. The nose-anus length

of male rats of one strain (Sprague-Dawley) was increased due to treatment, but was not observed in any of the other animals. Male rats were less tolerant of thyroactive preparations than female.

The growth rate of male guinea pigs was slightly accelerated by mild treatment (0.0025 to 0.0075 per cent thyroactive casein in the ration) for a short period of time, but the same treatment later became toxic with increase in age and arrival of warm weather. Growth rate of female guinea pigs was not affected for a few weeks, after which time treated animals ceased growing and lost weight.

Small amounts of thyroactive casein (0.0025 to 0.02 per cent of the ration) apparently did not affect growth of rabbits while larger amounts caused a depression of growth.

The effect of thyroactive casein on the organ weight of rats was studied. Extremely small dosages given to males did not affect the weight of any of the glands or organs weighed, although the thyroids of treated animals showed histological evidence of inactivity. Larger dosages given to either sex resulted in hypertrophy of heart, liver and kidneys. The effects on other glands was variable with strain and sex of animals.

The thyrotropic potency of the pituitaries of animals was markedly lowered by feeding thyroactive iodocasein.

15 figures, 26 tables, 7 pages of literature references. J.G.A.

154. The Mammogenic Hormones of the Anterior Pituitary. II. The Lobule-alveolar Growth Factor. J. P. MIXNER AND C. W. TURNER. Mo. Agr. Expt. Sta. Res. Bul. 378. 62 pages, illus. Sept., 1943.

1. Mammary lobule-alveolar growth responses were secured in castrate virgin female mice with anterior pituitary materials injected over periods of time ranging from four to ten days. These responses were not very predictable or repeatable on reassay.

2. The simultaneous injection of pituitary preparations and a small amount of estrone greatly reduced the amount of pituitary required to secure alveolar responses and the dosages of pituitary preparations injected were proportional to the per cent positive lobule-alveolar responses secured in groups of assay mice.

3. In the development of an assay method for the mammogenic lobule-alveolar growth factor, a ten-day assay period was found to be optimal.

4. The length of time elapsing between ovariectomy of the assay mice and the beginning of injection affects the mammary response secured; the shorter the time, the greater the mammary response.

5. An assay for the mammogenic lobule-alveolar growth factor was formulated. A mouse unit of this factor was defined as the amount of material required per mouse injected over a ten-day period to obtain minimal lobule-alveolar growth in 50 ± 10 per cent of ten or more castrate nulliparous

female mice when a total of 75 I.U. of estrone is simultaneously injected. Injection of the assay animals should start immediately after ovariectomy unless they are first primed with estrogen for several days preliminary to the start of injections.

6. Estrone in amounts of 40 I.U. to 133 I.U. were found to synergize best with one mg. of progesterone in stimulating mammary lobule-alveolar growth. Greater or smaller amounts of estrone did not give optimum synergism with progesterone.

7. Progesterone or pregneninolone alone caused lobule-alveolar growth. However, five or six times as much was required as if estrogen was also injected.

8. Although 2400 I.U. of estrone was able to completely inhibit the activity of a mouse unit of progesterone (one mg.), it was unable to inhibit the activity of a mouse unit of a pituitary preparation.

9. As a result of a series of experiments with progesterone, pregneninolone, pituitary extracts and estrogen, it was suggested that estrogen enhances the activity of progesterone and pituitary materials in stimulating mammary lobule-alveolar growth by acting directly on the stromal tissue surrounding the mammary gland producing an increased hyperemia and vascularity associated with an increased permeability of the vascular system. This condition would allow a circulating pituitary mammogen to be maximally effective in causing mammary gland growth.

10. Both estradiol benzoate and diethylstilbestrol were able to substitute for estrone in conjunction with progesterone in enhancing mammary lobule-alveolar growth.

11. Assays of various types of pituitary extracts showed that the mammogenic lobule-alveolar growth factor is protein in nature. These assays also indicate that this factor is not identical with lactogen, thyrotropin or gonadotropin.

12. Progesterone, pregneninolone, desoxycorticosterone, dehydroandrosterone, diethylstilbestrol, acetoxy-pregnenolone, and methyl testosterone ranked in the above order in their ability to stimulate mammary lobule-alveolar growth.

13. High environmental temperature inhibited the ability of progesterone and estrone to stimulate mammary lobule-alveolar growth. This same high temperature was unable to inhibit the ability of a pituitary preparation to stimulate lobule-alveolar growth.

14. Thyroxine in suitable amounts increased by about 33% the efficiency of progesterone in stimulating lobule-alveolar growth.

15. Thyroidectomy greatly decreased the efficiency of both progesterone and pituitary preparations in stimulating mammary lobule-alveolar growth.

16. Virgin female goats injected daily with twenty or thirty mg. of progesterone plus 100 or 150 micrograms of diethylstilbestrol, respectively,

for sixty days were stimulated to develop mammary glands similar to that seen in midpregnancy. Twelve days additional treatment with 0.25 mg. daily of diethylstilbestrol caused an initiation of secretion in these mammary glands similar to that seen at the time of parturition.

17. The response of virgin female goats to diethylstilbestrol in regard to mammary lobule-alveolar growth was extremely variable. In some cases very slight stimulation of the lobule-alveolar system was effected while in others a considerable development was secured.

18. Lobule-alveolar growth secured with diethylstilbestrol injections in goats was not histologically typical of that seen in normal lactating glands. The alveoli were much larger and less dense than normal lactating alveoli. Abnormal papillae-like structures were seen protruding into the lumina of the alveoli.

19. The over-all picture of mammary gland development as affected by the various endocrine glands was discussed.

20 figures, 18 tables, 6 pages of literature references. J.G.A.

155. The Effect of Thyroxine and Dinitrophenol on Sperm Metabolism. HENRY A. LARDY AND PAUL H. PHILLIPS, Dept. Biochem., Univ. Wis. Jour. Biol. Chem., *149*, No. 1: 177. 1943.

Dinitrophenol, a substance which stimulates tissue respiration, stimulated both the glycolysis and respiration, in the presence of metabolites, of bull spermatozoa, but it inhibited endogenous respiration. Dinitrophenol inhibited sperm motility and this could be prevented, to some extent, by the addition of glucose, lactate, or pyruvate.

"Thyroxine in 1:75,000 dilution inhibited respiration of bull spermatozoa and stimulated glycolysis. Orthothyroxine, an isomer of low physiological activity, did not significantly affect either glycolysis or respiration."

A.O.C.

MISCELLANEOUS

156. Reducing Hazards of Winter Truck Operation. E. G. QUESNEL, Dir. of Safety, The Borden Co. Milk Dealer, *33*, No. 4: 24. Jan., 1944.

The protection of life and the prevention of accidents, particularly under extra hazards of winter driving when streets are icy, snowy, and full of ruts, is of first importance in the operation of milk delivery trucks. The driver is admonished to distribute load evenly, to keep windshield clear, avoid use of brakes, keep out of ruts, shift gears on hills, brake with engine, drive slowly and carefully and check motor combustion and exhaust. Extra precautions should be taken in meeting, following, and passing other cars and trucks. C.S.T.

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THE HUMAN SIDE OF *Flavor*

In this age when the research staffs and bureaus endeavor to reduce everything to rigid rules and simplified regulations, the art of flavoring upsets all the calculations. Flavor just won't be regimented!

The simple reason is: the individual reactions of our senses are beyond the reach of the rule-makers. And it is the human side of flavor that really counts.

And so, intensive study of the working of the senses is an important part of the food man's stock in trade, for he is a realist enough to know that the human system relies solely upon its five senses to record everything.

Of these, the senses of hearing, sight and touch play relatively unimportant parts in the appreciation of fine flavoring. Yet, they are the three about which most is known.

The two remaining—taste and smell—present many mysteries of operation which are not too well known by many experts and most individuals. Yet these two senses are the very crux of the art of flavoring.

Common sense deductions coupled with published knowledge present this picture of what goes on "backstage" in the human tasting apparatus . . .

The taste organs, located in the mouth, virtually complete their job by telling us that a food is either bitter, salt, sour or sweet. This information alone would not give us any clue as to whether the food is flavored with vanilla, chocolate, coffee or tutti-frutti. It is obvious that the sense-of-smell must contribute the aroma-perception that is generally referred to as "taste."

The facts seem to be that the sense-of-smell performs two different functions. The well-known one is the nose's ability to record outside odors. The lesser known is the "inside job"—the recording of aromatic flavors.

Even before the food is tasted, the warmth of the tongue causes the aromatics to vaporize, and to pass by way of canals from the roof of the mouth to the nose, where the particular kind of aroma is identified.

A severe cold in the head produces a blockage in these back nasal passages, preventing anything but a blurred sensation of the delicate aromas of the food we eat. But the bitterness of medicine or the salty tang of a strong gargle seems to be recorded by the mouth with equal vigor. We actually lose our sense-of-smell, but not our sense-of-taste.

This study reveals one of the reasons why it is necessary to combine additional vanillin, from other sources, with the vanillin and other constituents of the vanilla bean in order to deliver the full, rounded, aromatic vanilla flavor to ice cream. The mere fact that ice cream is consumed cold means that the vaporizing of the aromatics, from the tongue to the nose, is slower than with a hot food.

Here again, checking with everyday occurrences emphasizes this point. A sizzling steak gives off aromatics while it is being served, whereas no aroma arises from a plate of ice cream.

The flavoring of dairy products is indeed an art. The factors that must be taken into consideration involve chemical and physical changes, absorption, adsorption—in fact, everything all the way back to the feed that Elsie had for breakfast. But the chief consideration is the human apparatus for recording the goodness of good things to eat. Because, with flavor, the senses have the last say.

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The American Dairy Science Association was organized to advance the general welfare of the dairy industry, especially by the improvement of dairy instruction by the stimulation of scientific research in all phases of the subject and by improvement in methods of conducting extension work.

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The dues are $5.00 a year, $3.00 of which is for a year's subscription to the *Journal of Dairy Science*. Correspondence regarding membership and dues should be addressed to R. B. Stoltz, Ohio State University, Columbus, Ohio.

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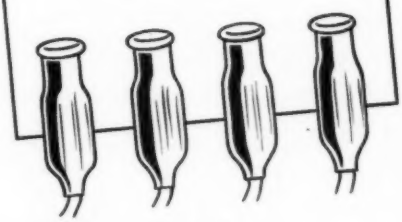

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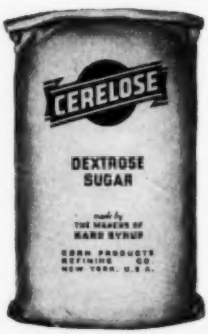

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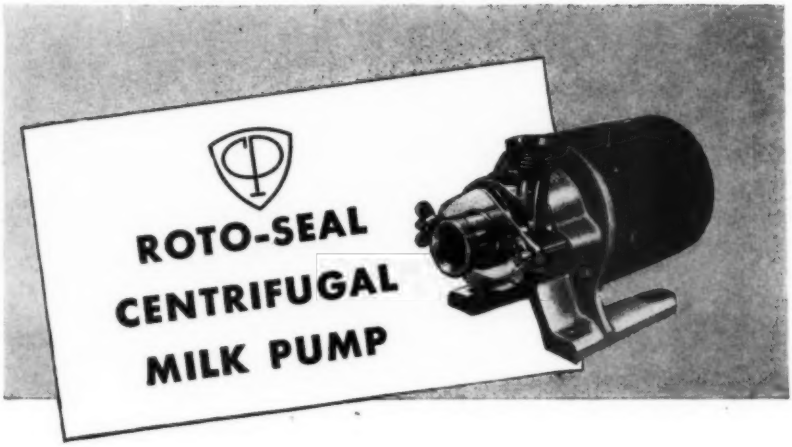

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